

*Jarman's  
Qualitative Analysis.*

K1064

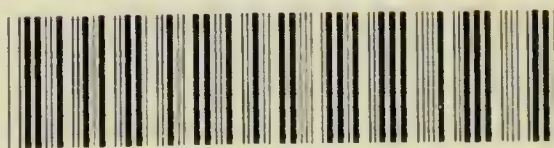
1/6

Notes on Qualitative Analysis  
concise & explanatory

By H. T. H. Fenton

Cambridge University Press  
1883

Med  
K1064



22102072323

20/11/02  
206





12733

SYSTEMATIC COURSE  
OF  
QUALITATIVE ANALYSIS,  
ARRANGED IN  
TABLES.

By GEORGE JARMAIN, F.C.S.,

PROFESSOR OF CHEMISTRY AT HUDDERSFIELD COLLEGE, HUDDERSFIELD COLLEGIATE SCHOOL,  
HALIFAX WORKING MEN'S COLLEGE, ETC.,  
REVISER OF BUCKMASTER'S CHEMISTRY, NEW EDITION,  
PUBLIC ANALYST FOR THE BOROUGH OF HUDDERSFIELD,  
EXAMINER ON WOOL DYEING TO THE SOCIETY OF ARTS.

FOR THE USE OF

SCIENCE CLASSES, SCHOOLS, & PRIVATE STUDENTS.

**THIRD EDITION.**

LONDON: LONGMANS, GREEN, READER, & DYER:  
SIMPKIN, MARSHALL, & CO.  
MANCHESTER: JOHN HEYWOOD.

AND MAY BE HAD OF ALL BOOKSELLERS.

19 222 633

10927

WELLCOME INSTITUTE LIBRARY	
Coll	we!MOmec
Call	
No	00



## PREFACE.

---

A THIRD Edition of this little work having been called for, the author has been encouraged to revise it again very carefully in order that it may be more completely adapted to meet the requirements of the class of students for whom it was originally designed. A further experience of its use, as an adjunct to the teaching of Qualitative Analysis, has enabled him to make a few alterations which, it is hoped, will facilitate the study of this most interesting and useful branch of the Chemical Science. Without altering the lines on which the original work was based, the author has modified some portions of it in order that it may be more systematic and in accordance with the best large standard works on Qualitative Analysis in existence. The author is most grateful for the encouragement he has received from Chemical Students since it was first used, and for the many kind notices of it which have been forwarded to him, and he trusts that the same favour may be extended to it by the new race of students who are joining our Science Classes in increasing numbers.

84, *Northgate, Huddersfield,*  
*December 1st, 1875.*

## PREFACE TO THE SECOND EDITION.

---

AN experience of two years' teaching with the First Edition of this little work, and with many grades of students, has enabled me to make a few necessary alterations and additions in revising it for the press for a Second Edition. Some new tests have been introduced, and the preliminary examination of substances has been amplified. A Table of Solubilities has also been added, which, it is hoped, will afford considerable assistance to the student. The book, however, has not been enlarged beyond my original intention, which was that the work should be of such a size that the average student might be able to master it in a reasonable time, that it should embrace all the best modern analytical processes, and that its price should be within the reach of any student. These objects, I believe have been attained in the present edition, which I trust will meet with the same favour that was extended to the first one.

84, Northgate, Huddersfield,  
Nov. 1, 1872.

---

## PREFACE TO THE FIRST EDITION.

---

THIS little work has been prepared as a companion to the Author's Revised Edition of Buckmaster's Chemistry, and is intended for the use of science students who have had an elementary course of instruction in Chemistry.

The tables for the detection of a single acid and base have been prepared specially for the use of candidates for the Middle Class Examinations.

The tables for the detection of acids and bases in mixtures have been prepared for students who intend to compete for the higher classes of prizes awarded under the new regulations of the Science and Art Department.

The Author has, as far as possible, introduced processes of *separation*, rather than of mere *detection*, in order that the student may the more readily prepare himself for quantitative analysis.

It is hoped that these tables will be found sufficiently concise and practical to enable the student to become acquainted with this interesting and important department of Chemistry in a reasonable time.

Huddersfield, October 1st, 1870.



# CONTENTS.

	PAGE
Directions to the Student ... ..	7
Reagents and Apparatus ... ..	9
Reactions of the Metals :—	
Group 1 ... ..	11
„ 2 ... ..	12
„ 3 ... ..	14
„ 4 ... ..	17
„ 5 ... ..	18
Reactions of the Acids :—	
Group 1 ... ..	19
„ 2 ... ..	21
„ 3 ... ..	22
Organic Acids ... ..	23
Preliminary Examination of Substances ... ..	25
„ „ for Bases ... ..	26
„ „ for Acids ... ..	29
Preparation of the Solution ... ..	29
Tables for the Analysis of Single Salts :—	
For the Metal or Base ... ..	30
For the Acid ... ..	36
Tables for the Analysis of Mixtures :—	
For the Metals or Bases ... ..	39
For the Acids ... ..	48
Explanatory Notes to Tables ... ..	50
The Solubility of Salts ... ..	53
Table of „ ... ..	54
Results of Analysis, form for ... ..	56



Digitized by the Internet Archive  
in 2016

<https://archive.org/details/b28134059>

## DIRECTIONS TO THE STUDENT.

---

THE reagents in constant use should be prepared by the student before he commences to test or analyse. Those described as being for occasional use may be prepared when required, but it will save time if they be kept ready for use.

The list of apparatus will be found to embrace everything that is required for the operations described in this work.

The student should first endeavour to verify and familiarise himself with the reactions of the metals and acids, and not pass over any of them until he is quite certain that he understands the reaction; for this purpose he should write out the equation which explains it in every doubtful case. As the formula, or name of the precipitate is given, the student will have no difficulty in doing this.

The student should try to master the use of the blowpipe, and not rest satisfied until he can keep up a steady blast, whilst he is still breathing through his nose.

He may next proceed to the preliminary examination of a salt by the process given at page 26, and he should make a practice of noting down all his observations for future reference, both in this examination and also when he uses the Tables, and he should on no account neglect to use the confirmatory tests. He may then proceed to examine the salt by the Tables for the detection of one acid and one base; he should practise himself in every group, first determining the group by Table I., and then the individual metal by the Table to which he is referred. The detection of the acid after this will be an easy matter, especially if he has been careful in his preliminary examination.

In the analysis of mixtures constant reference to the notes is recommended until they can be remembered; after a time the student will be able to dispense, in a great measure, with the Tables; but he should not rest satisfied until he understands the chemical change involved in every step of his operations.

The student is strongly recommended to record the results of his analysis according to the form given on page 56.

All test-tubes and vessels used in analytical operations must be kept scrupulously clean, otherwise the student will suffer much disappointment and vexation. Sulphuric or hydrochloric acid, or caustic soda, will generally remove any adhering matter which does not readily yield to the brush. After being cleansed the vessels should be repeatedly washed out with clean water, and finally with distilled water. A rigid adherence to the foregoing directions will alone insure success.

Materials should not be wasted by using more than is requisite for a reaction, and the whole of the substance at the disposal of the student should never be used at once, in case unforeseen accidents should occur.

## REAGENTS.

The following reagents and apparatus will be found suitable and sufficient for all the operations described in this work.

### *List of Fluid Reagents in constant use.\**

In bottles of about 4 oz. capacity.

Hydrochloric acid (dilute), $\text{HCl}$ , pure	...	...	Add 1 oz. of strong acid to 3 oz. $\text{OH}_2$ .
Sulphuric acid (dilute), $\text{SO}_2\text{Ho}_2$	„	...	„ „ „
Nitric acid (dilute), $\text{NO}_2\text{Ho}$	„	...	„ „ „
Sodic hydrate, $\text{NaHo}$ , common	„	...	$\frac{1}{2}$ oz. in 4 oz. $\text{OH}_2$ .
Sulphuretted hydrogen, $\text{SH}_2$ , washed	...	...	A saturated solution.
Hydric-ammonic sulphide, $\text{SHAm}$ (solution of $\text{SH}_2$ in $\text{AmHo}$ ).	...	...	
Ammonic hydrate (ammonia, $\text{AmHo}$ ), pure	...	...	1 oz. strong $\text{AmHo}$ to 3 oz. $\text{OH}_2$ .
Ammonic chloride, $\text{AmCl}$ , pure	...	...	$\frac{1}{4}$ oz. in 4 oz. $\text{OH}_2$ .
Ammonic carbonate, $\text{COAmo}_2$	...	...	1 oz. in $3\frac{1}{2}$ oz. $\text{OH}_2$ and $\frac{1}{2}$ oz. $\text{AmHo}$ .
Sodic carbonate, $\text{CONao}_2$ , pure	...	...	$\frac{1}{2}$ oz. in 4 oz. $\text{OH}_2$ .
Baric chloride, $\text{BaCl}_2$ , common	...	...	$\frac{1}{2}$ oz. in 4 oz. $\text{OH}_2$ .
Baric hydrate, $\text{BaHo}_2$	„	...	A saturated solution.
Calcic hydrate (lime water), $\text{CaHo}_2$ , common	...	...	A clear saturated solution.
Methylated spirit, free from gum.	...	...	

In bottles of about 2 oz. capacity.

Potassic ferrocyanide, $\text{K}_4\text{FeCy}_6$ , common	...	1 dram in 2 oz. $\text{OH}_2$ .
Hydric-disodic phosphate, $\text{POHoNaO}_2$ , common	...	$\frac{1}{4}$ oz. in 2 oz. $\text{OH}_2$ .
Ammonic oxalate	...	1 dram in 2 oz. $\text{OH}_2$ .
Ferric chloride, $\text{Fe}_2\text{Cl}_6$	...	1 dram in 2 oz. $\text{OH}_2$ .
Plumbic acetate, common	...	1 dram in 2 oz. $\text{OH}_2$ .
Acetic acid, pure	...	Concentrated acid.

In bottles of 1 oz. capacity.

Platinic chloride, $\text{PtCl}_4$ , pure	...	$\frac{1}{4}$ dram in 1 oz. $\text{OH}_2$ .
Argentie nitrate, $\text{NO}_2\text{Ago}$	„	$\frac{1}{2}$ dram in 1 oz. $\text{OH}_2$ .
Cobaltous nitrate, $\text{N}_2\text{O}_4\text{Coo}$ , pure	...	$\frac{1}{2}$ dram in 1 oz. $\text{OH}_2$ .

### *List of Solid or Dry Reagents in constant use.*

In 2 oz. wide-mouthed corked bottles.

Sodic carbonate, $\text{CONao}_2$ , anhydrous (re-crystallised washing soda dried.)	...
Potassic nitrate, $\text{NO}_2\text{Ko}$ , pure, needles or powder.	...
Borax, $\text{B}_4\text{O}_5\text{NaO}_2$ , anhydrous, powder.	...
Fusion mixture.—Anhydrous potassic and sodic carbonates mixed in equivalent proportions, say 13 parts of the former to 10 of the latter.	...

### *List of Fluid Reagents occasionally used as Special Tests, &c.*

In 16 oz. bottles, stoppered.

Hydrochloric acid, strong,	$\text{HCl}$ , pure.
Sulphuric acid	„ $\text{SO}_2\text{Ho}_2$ „
Nitric acid	„ $\text{NO}_2\text{Ho}$ „

In 3 or 4 oz. bottles, stoppered, or with corks.

Hydrofluosilicic acid, $\text{H}_2\text{SiF}_6$	...	A strong solution.
Potassic Cyanide $\text{KCy}$	...	$\frac{1}{2}$ oz. in 4 oz. $\text{OH}_2$ .

\* The solutions must be filtered if not quite clear. Distilled water or clear steam water must be used for the preparation of the fluid reagents. The water must give no ppt. or cloud with  $\text{BaCl}_2$  or  $\text{NO}_2\text{Ago}$ ; and there should be no residue when a few drops are evaporated on a watch-glass.



Barie carbonate, $\text{COBaO}''$ , suspended in water	1 oz. in 4 oz. $\text{OH}_2$ .
Magnesian sulphate, $\text{SO}_2\text{MgO}''$ , common	$\frac{1}{2}$ oz. in 4 oz. $\text{OH}_2$ .
Potassic chromate, $\text{CrO}_2\text{K}_2\text{O}_2$ „	$\frac{1}{2}$ oz. in 4 oz. $\text{OH}_2$ .
Calcic sulphate, $\text{SO}_2\text{CaO}''$ „	A saturated solution.
Calcic chloride, $\text{CaCl}_2$ „	$\frac{1}{2}$ oz. in 4 oz. $\text{OH}_2$ .
Potassic ferrieyanide, $\text{K}_6\text{Fe}_2\text{Cy}_{12}$ , common	1 dram in 3 oz. $\text{OH}_2$ .
Sulphindigotic acid	{ Solution of indigo in strong warm sulphuric acid. Dilute with water.
Starch paste.	
Tartaric acid, common, or Picric acid	1 oz. in 4 oz. $\text{OH}_2$ .
Chlorine water	Water saturated with chlorine gas.
Chloride of soda, $\text{ClNaO}$	{ A clear solution of bleaching powder, precipitated with $\text{CONaO}_2$ , and the $\text{UOCaO}''$ filtered off.
Carbonic disulphide, $\text{CS}_2$ .	
Ammonic molybdate	{ $\frac{1}{4}$ oz. dissolved in $\text{AmHO}$ , and the solu- tion added to excess of nitric acid.
Sodic acetate...	
Mercuric chloride...	$\frac{1}{2}$ oz. in 4 oz. $\text{OH}_2$ .
Stannous chloride...	$\frac{1}{4}$ oz. in 4 oz. $\text{OH}_2$ .
	$\frac{1}{2}$ oz. in 4 oz. $\text{OH}_2$ .

*List of Solid or Dry Reagents occasionally used as Special Tests, &c.*

- ✓ Calcic hydrate (slaked lime), in paste or powder.
- ✓ Manganic oxide,  $\text{MnO}_2$ , common.
- Microcosmic salt,  $\text{POHoAmONaO}$ , common.
- ✓ Ferrous sulphate (protosulphate of iron),  $\text{SO}_2\text{FeO}''$ , pure.
- Potassic cyanide  $\text{KC}_2$ .
- ✓ Blue and red litmus and turmeric papers.

*List of Suitable Apparatus.*

	£	s.	d.
✓ 1 wash-bottle	0	1	2
1 sulphuretted hydrogen apparatus, with wash bottle	0	1	0
1 nest of 4 beakers, 3 to 9 oz.	0	1	9
2 Porcelain evaporating basins, 2 oz. and 4 oz.	0	0	11
4 flasks, 4 oz., 8 oz., 16 oz., and 20 oz.	0	2	3
3 funnels, two 2 in., and one 3 in.	0	0	7
1 quire white filtering paper	0	1	0
1 Bunsen burner	0	1	6
Or 1 spirit lamp, 4 oz., 1s.			
1 Berlin porcelain crucible and cover, $\frac{1}{2}$ oz.	0	0	8
1 pair of brass or iron crucible tongs, 7 inch (6 inch 1/2)...	0	1	2
1 Wedgewood ware mortar and pestle, 4 oz.	0	1	2
1 2-oz. stoppered retort	0	0	7
$\frac{1}{2}$ lb. tubing and rod, various	0	0	8
1 doz. test-tubes, $6 \times \frac{1}{2}$ inch, or $5 \times \frac{5}{8}$	0	1	0
1 doz. test-tubes, $6 \times \frac{3}{4}$ inch	0	1	2
2 boiling tubes, $8 \times 1\frac{1}{4}$ inch	0	0	6
1 test-tube brush...	0	0	3
1 test-tube stand to hold 12	0	1	3
1 piece of wire gauze	0	0	3
1 piece of platinum-foil, 2 in. $\times$ 1 in., and 3 in. Pt. wire	0	1	3
1 Black's blowpipe	0	0	9
6 bulb-tubes, samples	0	0	2
1 retort-stand, 3 rings, 15 inch. high	0	3	6
6 watch-glasses	0	0	6
Vulcanized indiarubber tubing, $\frac{1}{4}$ in. bore, 4d. per foot.			

£1 5 0



# SYSTEMATIC COURSE OF QUALITATIVE ANALYSIS.

## REACTIONS OF THE METALS.

THE reactions given below are those upon which most reliance is placed by chemists ; additional reactions will, however, be found on referring to the Author's edition of "Buckmaster's Chemistry."

The names of the most suitable substances to employ for exercises in the application of the re-agents are given in italics.

The student is strongly recommended to verify and familiarise himself with the reactions before proceeding to the systematic course.

Distilled water must be used in testing, and in all analytical operations.

### GROUP I.

#### METALS PRECIPITATED BY HCl AS CHLORIDES.

##### **Ag.**—*Argentio nitrate*

1. Hydrochloric acid, HCl, gives a white ppt.\* of AgCl, which is insoluble in hot water and nitric acid, but soluble in AmHo.

1A. Potassia chromate,  $\text{CrO}_2\text{Ko}_2$ , gives a purple red precipitate of argentic chromate,  $\text{CrO}_2\text{Ago}_2$ , which becomes white on addition of HCl, from formation of AgCl.

2. Mixed with  $\text{CONao}_2$ , and heated on charcoal before the blow-pipe : brilliant white malleable metallic beads.

##### **Hg'**<sub>2</sub>.—*Mercurous nitrate.*

3. Hydrochloric acid, HCl, gives a white ppt. of calomel,  $\text{Hg}'_2\text{Cl}_2$ , which is insoluble in hot water, and blackened by AmHo, being converted into  $\text{NH}_2\text{Hg}'_2\text{Cl}$ .

3A. Sodio hydrate, NaHo, gives a black ppt. of mercurous hydrate,  $\text{Hg}'_2\text{Ho}_2$  (distinction from a mercuric salt.)

4. The dry substance mixed with sodio carbonate,  $\text{CONao}_2$ , and heated in a tube closed at one end, gives a grey sublimate of metallic mercury, which, by rubbing, may be united into a distinct globule.

##### **Pb.**—*Plumbic acetate or nitrate.*

5. HCl gives a white ppt. of  $\text{PbCl}_2$ , which is soluble in much hot water, but unchanged in colour by AmHo, being converted into the insoluble white plumbic oxychloride,  $\text{PbO}, \text{PbCl}_2$ .

---

\*The abbreviation ppt. is used here and elsewhere for precipitate.

6. Potassic chromate,  $\text{CrO}_2\text{Ko}_2$ , gives a bright yellow ppt. of  $\text{CrO}_2\text{Pbo}''$ , which is nearly insoluble in dilute nitric acid,  $\text{NO}_2\text{Ho}$ , but soluble in sodic hydrate,  $\text{NaHo}$ .

7. Dilute sulphuric acid,  $\text{SO}_2\text{Ho}_2$ , gives a white ppt. of plumbic sulphate,  $\text{SO}_2\text{Pbo}''$ , immediately in concentrated solutions, but only after a time in very dilute ones: addition of methylated spirit favours the precipitation.

8. Mixed with sodic carbonate,  $\text{CONao}_2$ , and heated on charcoal before the blowpipe: malleable metallic beads, which leave a black mark on paper when drawn over it.

## GROUP II.

### METALS PRECIPITATED BY SULPHURETTED HYDROGEN AS SULPHIDES AFTER SEPARATION OF GROUP I.

*Subdivision 1.*—Metals whose sulphides are insoluble in alkaline sulphides and hydrates:—

**Hg''.**—*Mercuric chloride.*

9. Sulphuretted hydrogen solution added by small portions at a time produces, first, a white ppt., then a yellow one, and, lastly, a black one, as more is added.

10. A strip of zinc when boiled in a solution of mercuric salt, to which a few drops of  $\text{HCl}$  have been added, becomes amalgamated and brittle.

10A. Sodic hydrate,  $\text{NaHo}$ , gives a dark yellow ppt. of mercuric hydrate,  $\text{HgHo}_2$ , which becomes dense and brick red on boiling ( $\text{HgO}$ , distinction from a mercurous salt).

11. Stannous chloride,  $\text{SnCl}_2$ , added in small quantity, produces a white ppt. of  $\text{Hg}_2\text{Cl}_2$ , which turns grey as more  $\text{SnCl}_2$  is added, being reduced to metallic mercury.

12. Reaction (4) is also applicable to mercuric compounds.

**Pb.**—*See reactions of lead under Group I.*

**Bi.**—*Bismuthous nitrate or chloride.*

13. Water added in large quantity to a solution of bismuth, to which  $\text{HCl}$ , or ammoniac chloride,  $\text{AmCl}$ , has been added, gives a white ppt. of a basic chloride,  $\text{BiOCl}$ , which is insoluble in tartaric acid.

14. Potassic chromate,  $\text{CrO}_2\text{Ko}_2$ , produces a yellow powdery ppt. of  $\text{Cr}_2\text{O}_5 (\text{BiO}_2)_2$ , easily soluble in dilute nitric acid,  $\text{NO}_2\text{Ho}$ , insoluble in sodic hydrate,  $\text{NaHo}$ . See 6.

15. Mixed with sodic carbonate,  $\text{CONao}_2$ , and heated on charcoal before the blowpipe in the reducing flame: brittle metallic beads are obtained, and a yellow incrustation covers the charcoal.

**Cu.**—*Cupric sulphate, nitrate, or chloride.*

16. Ammonia,  $\text{AmHo}$ , added in small quantity, gives a greenish blue ppt. of cupric hydrate,  $\text{CuHo}_2$ , which re-dissolves to a clear fluid of a fine azure blue colour when excess of  $\text{AmHo}$  is added, ammonio-cupric sulphate being formed.

17. A piece of bright iron, dipped into a cupric solution, made acid with  $\text{HCl}$ , becomes coated with metallic copper: if clean iron borings be boiled in the solution it will lose its blue colour, the copper being entirely deposited on the iron.

18. Sodic hydrate,  $\text{NaHo}$ , gives a bulky light blue ppt. of cupric hydrate,  $\text{CuHo}_2$ : if excess of  $\text{NaHo}$  be added, and the mixture boiled, the ppt. becomes black and powdery, being converted into cupric oxide,  $\text{CuO}$ .

19. If a piece of platinum-foil be dropped into a solution of copper made acid with  $\text{HCl}$ , and then a strip of sheet zinc, so that the two metals touch one another, the platinum will become coated with copper.

20. Mixed with sodic carbonate,  $\text{CONaO}_2$ , and potassic cyanide,  $\text{KCy}$ , and heated for some time on charcoal before the inner blowpipe flame—red metallic scales are obtained. If these should not be perceptible, the portion of charcoal in which they are imbedded is scraped off into a mortar, ground up, and the charcoal washed away with water, the particles of copper will remain in the mortar.

**Cd.**—*Cadmie iodide or sulphate.*

21. Hydric-ammonic sulphide,  $\text{SHAm}$ , gives a yellow ppt. of cadmic sulphide;  $\text{CdS}$ , insoluble in alkalis and alkaline sulphides.

22. Mixed with sodic carbonate,  $\text{CONaO}_2$ , and heated on charcoal before the inner blowpipe flame: a yellow or reddish-yellow incrustation of cadmic oxide,  $\text{CdO}$ .

*Subdivision 2.*—Metals whose sulphides are soluble in alkaline sulphides and hydrates:—

**Sn."**—*Stannous chloride.*

23. Sulphuretted hydrogen,  $\text{SH}_2$ , gives a chocolate-coloured ppt. of stannous sulphide,  $\text{SnS}$ , soluble in sodic hydrate,  $\text{NaHo}$ .

24. Mercuric chloride,  $\text{HgCl}_2$ , gives a white ppt. of mercurous chloride,  $\text{Hg}'_2\text{Cl}_2$ , when added in excess (see reaction 11).

25. A strip of zinc added to a solution made acid with  $\text{HCl}$  becomes coated with metallic tin, either in grey laminæ or a spongy mass. Platinum-foil in contact with the strip of zinc does not become blackened.

26. Mixed with sodic carbonate,  $\text{CONaO}_2$ , and potassic cyanide,  $\text{KCy}$ , and heated on charcoal before the blowpipe: malleable beads of metallic tin are obtained.

**Sn<sup>iv</sup>.**—*Stannic chloride.*

27. Sulphuretted hydrogen,  $\text{SH}_2$ , gives a yellow ppt. of stannic sulphide,  $\text{SnS}_2$ , soluble in  $\text{SHAm}$  and  $\text{NaHo}$ .

28. Sodic sulphate,  $\text{SO}_2\text{NaO}_2$ , added in excess, and the solution warmed, precipitates stannic hydrate,  $\text{SnHo}_4$ , or metastannic acid,  $\text{Sn}_5\text{O}_5\text{Ho}_{10}$ .

29. Reactions 25 and 26 also apply to stannic compounds.

**Sb.**—*Tartar emetic in  $\text{HCl}$ , or antimonious chloride.*

30. Sulphuretted hydrogen,  $\text{SH}_2$ , gives in acid solutions an orange-red ppt. of  $\text{Sb}_2\text{S}_3$ , soluble in  $\text{NaHo}$  and alkaline sulphides.



31. If a piece of platinum-foil be dropped into a solution of antimony made acid with  $\text{HCl}$ , and then a strip of sheet zinc, so that the two metals touch one another, the platinum will become coated with metallic antimony as a brown or black powder : free nitric acid must be absent.

32. Marsh's test.—A small quantity of the substance is introduced into an apparatus evolving pure hydrogen, and furnished with a jet. The escaping antimoniuiretted hydrogen gas,  $\text{SbH}_3$ , is then lighted ; the gas will burn with a bluish-green flame, fumes of antimonious oxide,  $\text{Sb}_2\text{O}_3$ , are evolved, and on pressing a cold dish upon the flame, a velvet-black stain or mirror of metallic antimony will be produced on the dish. If the jet be bent at right angles, and heated at a little distance from the end, a mirror will be formed in the tube on both sides of the heated part. The mirror on the dish is not dissolved by a drop of chloride of soda,  $\text{ClNaO}$  (Sodic hypochlorite). (Distinction from arsenic.)

33. Water precipitates from solutions of antimony, containing  $\text{HCl}$ , a basic chloride,  $\text{SbOCl}$ , which is soluble in tartaric acid.

34. Mixed with sodic carbonate,  $\text{CONaO}_2$ , and potassic cyanide,  $\text{KC}_y$ , and heated on charcoal before the inner blowpipe flame : brittle globules of metallic antimony are produced. If difficulty be experienced in obtaining the metallic globules, proceed as in 20.

**As.**—*Solution of arsenious anhydride in  $\text{HCl}$ .*

35. Marsh's test.—Treat the substance as in 32. Arseniuiretted hydrogen gas,  $\text{AsH}_3$ , is evolved, which, on being lighted, gives off fumes of arsenious anhydride,  $\text{As}_2\text{O}_3$ , and produces a black stain or mirror on a porcelain dish. The mirror on the dish is readily dissolved by a drop of chloride of soda,  $\text{ClNaO}$  (Sodic hypochlorite). (Distinction from antimony.)

36. Reinsch's test.—The solution is mixed with  $\text{HCl}$  and boiled with a clean piece of copper wire or foil. An iron-grey film of  $\text{Cu}_3\text{As}_2$  is deposited on the copper. The copper wire or foil is carefully washed, dried, and then heated in an open tube, the arsenic oxidises and deposits on the cool part of the tube in octahedral crystals of arsenious anhydride,  $\text{As}_2\text{O}_3$ , which may be seen with a lens.

36a. Add cuprie sulphate  $\text{SO}_2\text{CuO}$ , and then sodic hydrate,  $\text{NaHO}$ , in excess ; a fine green ppt. of arsenite of copper is thrown down.

37. Mixed with sodic carbonate,  $\text{CONaO}_2$ , and charcoal powder, and heated in a small bulb or arsenic tube : a black lustrous metallic ring on the cool part of the tube will be produced.

### GROUP III.

#### METALS PRECIPITATED BY HYDRIC-AMMONIC SULPHIDE, AFTER SEPARATION OF GROUPS I. AND II.

*Subdivision 1.*—Metals precipitated by ammonia,  $\text{AmHO}$ , in presence of excess of ammoniac chloride,  $\text{AmCl}$ , as hydrates :—

**Fe'''**.—*Ferric chloride or sulphate or iron alum.*

38. Potassic ferrocyanide,  $K_4FeCy_6$  gives a dark-blue ppt. of Prussian blue,  $Fe_4(FeCy_6)_3$ .

39. Potassic ferricyanide,  $K_6Fe_2Cy_{12}$ , gives no ppt., but deepens the colour of the solution to a darker brown.

40. Potassic sulphocyanide,  $KCsy$ , gives the solution a blood-red colour  $Fe_2Csy_6$  being formed.

41. Ammonia,  $AmHo$ ,\* gives a bulky reddish-brown ppt. of ferric hydrate,  $Fe_2Ho_6$ , insoluble in excess of ammonia,  $AmHo$ .

**Fe''**.—*Ferrous Sulphate or Chloride.*

42. Potassic ferrocyanide,  $K_4FeCy_6$  gives a bluish white ppt., which rapidly becomes blue by absorption of oxygen.

43. Potassic ferricyanide,  $K_6Fe_2Cy_{12}$ , produces a dark blue ppt. of  $Fe_3Fe_2Cy_{12}$  (*Turnbull's blue*).

44. Potassic sulphocyanide,  $KCsy$ , gives no ppt. or change of colour.

45. Ammonia  $AmHo$ ,\* produces a light-coloured ppt. of ferrous hydrate,  $FeHo_2$ , which speedily becomes dirty green, and, after a time, reddish-brown, from absorption of oxygen.

Presence of ammonic salts prevents the precipitation of ferrous hydrate by ammonia,  $AmHo$ .

**Al**.—*Alum, or aluminic chloride.*

46. Ammonia,  $AmHo$ , produces a bulky, semi-transparent, gelatinous ppt. of  $Al_2Ho_6$ , which becomes more opaque on heating. The ppt. is insoluble in excess of  $AmHo$ , unless the excess be very considerable.

47. Sodie hydrate,  $NaHo$ , also precipitates  $Al_2Ho_6$ , which is soluble in excess of  $NaHo$ . From this sodie solution the  $Al_2Ho_6$  is re-precipitated by ammonic chloride,  $AmCl$ . (Distinction from Zinc).

48. Heated on charcoal before the blow-pipe, then moistened with cobaltous nitrate, and heated again in the inner flame, a fine blue mass is obtained. (Distinction from Zinc).

**Cr**.—*Chrome alum, chromic chloride.*

49. Sodie hydrate,  $NaHo$ , precipitates  $Cr_2Ho_6$ , as a bluish-green ppt. Excess of  $NaHo$  redissolves the ppt., producing an emerald green fluid, from which the chromic hydrate,  $Cr_2Ho_6$ , is again precipitated by long boiling. Addition of ammonic chloride,  $AmCl$ , favours the separation of the ppt.

50. The solution made alkaline with sodie hydrate and then boiled with chloride of soda,  $ClNaO$ , for some time, becomes yellow from the formation of a chromate, and then, when acidified with acetic acid, precipitates chrome yellow,  $CrO_2Pbo$ ", from solutions of lead.

51. Chromium compounds give an emerald-green borax bead both in the outer and inner flame. (Distinction from copper).

52. Mixed with fusion mixture and a little potassic nitrate, and fused on platinum-foil or on a fragment of porcelain, a yellow mass of potassic and sodie chromate is obtained, the solution of which, acidified with acetic acid, precipitates  $CrO_2Pbo$ " from solutions of lead.

\* Organic acids and organic compounds, such as sugar, prevent the precipitation of ferrous and ferric hydrates by alkalis.

*Subdivision 2.*—Metals precipitated by hydric-ammonic sulphide, **SHAm**, as sulphides, after removal of Subdivision 1 :—

**Ni.**—*Nickelous sulphate.*

53. Sodid hydrate, **NaHo**, precipitates nickel as an apple-green coloured hydrate, **NiHo<sub>2</sub>**, which is insoluble in excess of **NaHo**.

54. Ammonia, **AmHo**, added in very small quantity, also precipitates **NiHo<sub>2</sub>**, which readily redissolves to a blue solution on adding more **AmHo**. Ammonic chloride prevents precipitation by **AmHo**.

54A. Potassic cyanide, **KCy**, gives a yellowish green ppt. of nickelous cyanide, **NiCy<sub>2</sub>**, which re-dissolves on adding more **KCy** to a brownish yellow solution, **2KCy**, **NiCy<sub>2</sub>**. This solution gives a black ppt. of nickelic oxide, **Ni<sub>2</sub>Ho<sub>6</sub>**, when treated with strong chloride of soda, **ClNao**, in the cold.

55. Compounds of nickel in the outer flame colour the borax bead reddish brown when cold. The bead is changed to a blue or dark purple when a little nitre is fused in it.

**Co.**—*Cobaltous nitrate.*

56. Sodid hydrate, **NaHo**, gives a blue ppt. of **CoHo<sub>2</sub>**, which is insoluble in excess, and turns green on exposure to the air, and pale red on boiling.

57. Ammonia, **AmHo**, precipitates **CoHo<sub>2</sub>**, of a bluish green colour : the ppt. readily dissolves in excess of **AmHo** to a reddish fluid, which turns brownish red on exposure to the air.

58. Potassic cyanide, **KCy**, gives a reddish brown ppt. of cobaltous cyanide, **CoCy<sub>2</sub>**, which redissolves in excess of potassic cyanide, **KCy**, becoming potassic cobalticyanide, **K<sub>6</sub>Co<sub>2</sub>Cy<sub>12</sub>**. This solution gives no ppt. when treated with strong chloride of soda, **ClNao**, in the cold.

59. Compounds of cobalt colour the borax bead blue, both in the inner and outer flame.

**Mn.**—*Manganous sulphate or chloride.*

60. Hydric-ammonic sulphide, **SHAm**, gives a light flesh-coloured ppt. of **MnS**, which becomes dark brown on exposure to air.

61. Sodid hydrate, **NaHo**, produces a whitish ppt. of **MnHo<sub>2</sub>**, which speedily turns brown upon exposure to air in an open vessel.

62. Ammonia, **AmHo**, gives the same ppt., unless ammonic salts be present, which prevent the precipitation.

63. Manganese compounds colour the borax bead amethyst in the outer flame when cold. The bead becomes colourless, or nearly so, in the inner flame.

64. Mixed with fusion mixture and a little potassic nitrate, **NO<sub>2</sub>Ko**, and heated on platinum-foil, a green mass of alkaline manganate is produced.

**Zn.**—*Zincic sulphate or chloride.*

65. Hydric-ammonic sulphide, **SHAm**, gives a white ppt. of **ZnS**.



66. Sodid hydrate,  $\text{NaHo}$ , precipitates zincic hydrate,  $\text{ZnHo}_2$ , as a white gelatinous ppt., and re-dissolves it as more  $\text{NaHo}$  is added. Addition of ammoniac chloride does not re-precipitate the  $\text{ZnHo}_2$ . (Distinction from Aluminium.)

67. Heated on charcoal before the blowpipe, then moistened with cobaltous nitrate, and heated again, a fine green mass is obtained. (Distinction from Aluminium.)

#### GROUP IV.

METALS PRECIPITATED BY AMMONIC CARBONATE IN PRESENCE OF AMMONIC CHLORIDE AS CARBONATES, AFTER REMOVAL OF PREVIOUS GROUPS.

**Ba.**—*Baric chloride or nitrate.* ✓

68. Calcic sulphate,  $\text{SO}_2\text{Cao}''$ , or dilute sulphuric acid, gives *immediately* a finely-divided white ppt. of baric sulphate,  $\text{SO}_2\text{Bao}''$ , which is insoluble in alkalies and dilute acids.

69. Potassic chromate,  $\text{CrO}_2\text{Ko}_2$ , gives a yellow ppt. of baric chromate,  $\text{CrO}_2\text{Bao}''$ , insoluble in acetic acid, but soluble in nitric and hydrochloric acids.

70. Hydrofluosilicic acid,  $\text{H}_2\text{SiF}_6$ , precipitates barium as baric silicofluoride,  $\text{BaSiF}_6$ , in the form of a colourless crystalline heavy precipitate. Addition of an equal volume of alcohol makes the precipitation complete.

71. If a fragment be placed in the loop of a platinum wire, and then held in the hottest part of the Bunsen flame, the upper part of the flame is coloured *yellowish-green*. Moistening the fragment with  $\text{HCl}$  or  $\text{SO}_2\text{Ho}_2$  will render this reaction more delicate.

**Sr.**—*Strontic nitrate or chloride.*

72. Calcic sulphate,  $\text{SO}_2\text{Cao}''$ , or dilute sulphuric acid, gives *after a time* a white ppt. of strontic sulphate,  $\text{SO}_2\text{Sro}''$ , which is slightly soluble in  $\text{HCl}$  and nitric acid,  $\text{NO}_2\text{Ho}$ , but insoluble in ammoniac sulphate,  $\text{SO}_2\text{Amo}_2$ , in concentrated solution. ✓

73. Potassic chromate,  $\text{CrO}_2\text{Ko}_2$ , and hydrofluosilicic acid,  $\text{H}_2\text{SiF}_6$ , do not precipitate strontium even from concentrated solutions.

74. If a fragment be treated as in 71, the flame will be coloured *intensely red*.

**Ca.**—*Calcic chloride.*

75. Ammoniac oxalate gives a white powdery ppt. of calcic oxalate even in very dilute solutions. The ppt. is insoluble in acetic and oxalic acid, but readily dissolves in  $\text{HCl}$  and  $\text{NO}_2\text{Ho}$ .

76. Calcic sulphate, dilute sulphuric acid, potassic chromate, and hydrofluosilicic acid, do not precipitate calcium from its solutions. (Distinctions from Barium and Strontium.)

77. If a fragment be treated as in 71, the flame will be coloured *yellowish-red or orange*.

## GROUP V.

## METALS NOT PRECIPITATED BY ANY OF THE GROUP REAGENTS.

**Mg.**—*Magnesian Sulphate.*

78. A mixture of ammoniac chloride,  $\text{AmCl}$ , and ammonia,  $\text{AmHo}$ , does not precipitate magnesium; but if hydric-disodic phosphate,  $\text{POHoNaO}_2$ , be now added, a white crystalline ppt. of  $\text{POAmoMgo}''$  is thrown down. In dilute solutions the precipitation is favoured by agitation, or stirring with a glass rod. The ppt. is insoluble in water containing ammonia, but readily dissolves in acids, even acetic.

79. Ammonia,  $\text{AmHo}$ , precipitates the hydrate  $\text{MgHo}_2$ , and ammoniac carbonate the carbonate,  $\text{COMgo}''$ , from neutral solutions, but the precipitation of these is prevented by the presence of ammoniac chloride.

79A. Heated strongly on charcoal before the blow-pipe, moistened with cobaltous nitrate and heated again, a pale pink mass is obtained. (Distinction from zinc and aluminum).

**K.**—*Potassic nitrate or chlorate.*

80. Platinic chloride,  $\text{PtCl}_4$ , gives a dense yellow ppt. of  $(\text{PtCl}_4, 2\text{KCl})$ , with concentrated acid or neutral solutions. Dilute solutions are precipitated only after a considerable time; very dilute ones not at all. The ppt. is but very slightly soluble in water or free acids, and it is insoluble in alcohol. The most convenient and delicate plan of applying the above test is to add a drop of  $\text{PtCl}_4$  to a few drops of the solution in a watch-glass or on a strip of glass, evaporate the mixture nearly to dryness, and then add alcohol.

81. Tartaric acid produces in strong neutral solutions a heavy crystalline ppt. of cream of tartar. The precipitation is favoured by shaking or stirring. Dilute solutions are not precipitated.

82. Picric acid behaves in a similar manner to tartaric acid, potassic picrate being precipitated.

83. If a fragment be treated as in 71,\* the flame is coloured *violet*. By looking at the flame through a piece of blue cobalt glass, it appears *purple or reddish-violet*: this colouration may be seen even when sodium compounds are present, the yellow sodium flame being cut off by the blue glass.

**Na.**—*Sodic carbonate, sulphate or chloride.*

84. Platinic chloride, tartaric acid, and picric acid produce no ppt. in solutions of sodium.

85.—The Bunsen flame is coloured *golden yellow* by a fragment treated as in 71.\* This colour cannot be seen through cobalt glass.

**Am'**—*Ammoniac chloride.*

86. Heated in a beaker, dish, or wide test tube with sodic hydrate,  $\text{NaHo}$ , or lime (powder or cream), ammonia gas,  $\text{NH}_3$ , is given off, which may be recognised by its smell. A piece of moistened turmeric paper held in the vessel, *without touching it*, is colored *brown*. For

---

\* See foot-note to Table VI.

detecting small quantities the beaker may be covered with a watch-glass or dish, to the bottom of which the turmeric paper is gummed. The paper will be coloured brown after standing some time if ammonium be present.

87. Heated on platinum-foil, ammonium compounds are volatilised, unless fixed acids, such as phosphoric, boric, &c., be present, in which case the acid is left.

88. Platinic chloride,  $\text{PtCl}_4$ , gives in concentrated acid and neutral solutions a dense yellow ppt. of  $(\text{PtCl}_4, 2\text{AmCl})$ . Tartaric acid also gives a white crystalline ppt. of hydric-ammonic tartrate. Weak solutions are not precipitated by these reagents.

89. Nessler's test for detecting traces of ammonia as in natural waters.—A few drops of the test added to the solution gives a brown ppt. of  $\text{NHg}_2\text{I}$ , or a yellowish brown colouration, according to the quantity of ammonia present. This reaction is too delicate for ordinary analysis.

## REACTIONS OF THE ACIDS.

THE ACIDS DO NOT ADMIT OF ANY WELL-DEFINED CLASSIFICATION.

### GROUP I.

**Acids which are precipitated from *neutral* solutions by baric chloride :—**

SULPHURIC ACID,  $\text{SO}_2\text{Ho}_2$ .—*Potassic or sodic sulphate.*

90. Baric chloride or nitrate gives a white powdery ppt. of  $\text{SO}_2\text{BaO}''$ , which is insoluble in dilute  $\text{HCl}$  or  $\text{NO}_2\text{Ho}$ .

91. Plumbic acetate produces a heavy white ppt. of plumbic sulphate,  $\text{SO}_2\text{Pbo}''$ .

92. Mixed with sodic carbonate,  $\text{CONao}_2$ , free from sulphate, and heated on charcoal before the inner blowpipe flame, sodic sulphide is formed, which will now evolve sulphuretted hydrogen when treated with an acid.

PHOSPHORIC ACID,  $\text{POHo}_3$ .—*Hydric di-sodic phosphate.*

93. To an aqueous solution of an alkaline phosphate add ammonic chloride, ammonia, and magnesian sulphate : a white crystalline ppt. of  $\text{POAmoMgo}''$  is produced. See 78 for properties of ppt.

94. To a hydrochloric acid solution of a phosphate containing not much free  $\text{HCl}$ , add excess of sodic acetate, and one drop of ferric chloride,  $\text{Fe}_2\text{Cl}_6$  : a yellowish white gelatinous ppt. of ferric phosphate is produced, insoluble in acetic acid, soluble in  $\text{HCl}$ .

95. Ammonic molybdate gives a finely-divided yellow ppt. in solutions made strongly acid with nitric acid : warming the fluid favours the precipitation : if the solution be dilute it must be set aside



for a few hours. Silicic acid gives a yellow colouration on warming the solution, but there is no ppt.

96. Argentic nitrate,  $\text{NO}_2\text{Ago}$ , gives a light-yellow ppt. of  $\text{POAgo}_3$  with neutral solutions, soluble in  $\text{AmHo}$  and  $\text{NO}_2\text{Ho}$ .

SILICIC ACID,  $\text{SiHo}_4$ .—*Potassic or sodic silicate.*

97. To a solution of a silicate add hydrochloric acid in excess, and evaporate in a dish to dryness; when cold, moisten with  $\text{HCl}$ , warm, and add water. White flakes of  $\text{SiO}_2$  will remain undissolved.

98. Insoluble silicates must be mixed with about four times their weight of fusion mixture, and fused on platinum-foil until evolution of  $\text{CO}_2$  ceases. The mass is then boiled with water, excess of  $\text{HCl}$  added, and the solution treated as in 97.

99. Ammonic chloride precipitates gelatinous silicic acid,  $\text{SiHo}_4$ , from its solutions.

99A. If a colourless silicate be fused in a bead of microcosmic salt, the silica floats about in the bead as a skeleton.

BORIC ACID,  $\text{BHo}_3$ .—*Borax.*

100. Add  $\text{HCl}$  to the solution till slightly acid, then dip a piece of turmeric paper halfway in, and remove it and dry it gently: the portion immersed will become red.

101. Boric acid or borates, moistened with sulphuric or hydrochloric acid, when introduced into the Bunsen flame on a loop of platinum wire, tinge it of a green colour. Phosphates and copper salts must be absent. Most borates swell up considerably when heated by themselves, and then shrink up and fuse into a transparent glass.

CARBONIC ACID,  $\text{COHo}_2$ .—*Calcic or sodic carbonate.*

102. Addition of  $\text{HCl}$  to a carbonate causes effervescence from expulsion of carbonic anhydride,  $\text{CO}_2$ . This heavy gas has little or no odour, and may be recognised by decanting it from the test-tube into a larger one, containing clear lime or baryta water. On closing the mouth of the test-tube and shaking, the lime water becomes milky from formation of calcic carbonate,  $\text{COCao''}$ , or baric carbonate,  $\text{COBao''}$ .

SULPHUROUS ACID,  $\text{SOHo}_2$ .—*Sodic sulphite.*

103. Add hydrochloric acid, and heat if necessary: the smell of burning sulphur is evolved.

104. Drop into the solution some granulated zinc, and then  $\text{HCl}$ : the odour of sulphuretted hydrogen is evolved.

OXALIC ACID,  $\left\{ \begin{array}{l} \text{COHo.} \\ \text{COHo.} \end{array} \right.$ —*Ammonic oxalate.*

105. Calcic chloride,  $\text{CaCl}_2$ , and all soluble lime salts, produce in solutions of oxalic acid and oxalates a white ppt. of calcic oxalate  $\text{C}_2\text{O}_2\text{Cao''}$ , which is insoluble in acetic acid. Addition of ammonia makes this reaction very delicate. See 75.

106. The dry compound, or concentrated solution, heated in a test-tube with strong sulphuric acid, evolves  $\text{CO}$  and  $\text{CO}_2$ , the former of which burns with a blue flame on applying a light.

106A. When oxalic acid or an oxalate is mixed with  $\text{MnO}_2$  and a few drops of strong sulphuric acid added, the mixture effervesces with evolution of  $\text{CO}_2$ , which may be tested for with lime or baryta water, as in 102.

HYDROFLUORIC ACID,  $\text{HF}$ .—*Fluor spar*.

107. The substance in solution or powder is mixed with strong sulphuric acid in a lead or tin capsule (a small tart-tin answers well), having a piece of glass coated with beeswax, with a design traced upon it, placed over it with the waxed side downwards: the glass will be etched where the design is traced. The glass may be cleaned by warming it before a fire or over a Bunsen flame, and wiping off the wax with a cloth when it is melted. The same reaction may be more readily seen as follows: A little of the substance is mixed with a drop of sulphuric acid on a strip of glass, and warmed for a few minutes; on cleaning the glass, and looking across its surface, the spot previously occupied by the substance will appear dull.

CHROMIC ACID,  $\text{CrO}_2\text{Ho}_2$ .—*Potassic chromate*.

108. Sulphuretted hydrogen,  $\text{SH}_2$ , added to an acid solution of a chromate, turns it green by reducing it to a chromic compound.

109. Sulphurous acid, or a soluble sulphite, has a similar effect.

110. Argentic nitrate,  $\text{NO}_2\text{Ago}$ , gives a dark purple red ppt. of  $\text{CrO}_2\text{Ago}_3$ .

111. Plumbic acetate produces a yellow ppt. of plumbic chromate, which is insoluble in acetic acid. See 6.

ARSENIOUS ACID,  $\text{AsHo}_3$ .—*Arsenious anhydride dissolved in HCl*.

See 35, 36, 36A, and 37.

## GROUP II.

**Acids which are precipitated from their neutral solutions by argentic nitrate:—**

HYDROCHLORIC ACID,  $\text{HCl}$ .—*Ammonic or sodic chloride*.

112. Argentic nitrate,  $\text{NO}_2\text{Ago}$ , gives a white curdy ppt. of  $\text{AgCl}$ , which is insoluble in dilute nitric acid, but soluble in ammonia, potassic cyanide, and sodic hyposulphite. The ppt. darkens on exposure to sunlight.

113. Mixed with  $\text{MnO}_2$  and sulphuric acid, and heated, chlorine gas is evolved, which may be recognised by its odour, colour, and bleaching action on moist test-paper.

114. Plumbic acetate gives a white ppt. of  $\text{PbCl}_2$ , which is soluble in much boiling water.

HYDROBROMIC ACID,  $\text{HBr}$ .—*Potassic bromide*.

115. Argentic nitrate,  $\text{NO}_2\text{Ag}$ , produces a yellowish white ppt. of  $\text{AgBr}$ , insoluble in dilute nitric acid, slightly soluble in ammonia, but readily soluble in potassic cyanide and sodic hyposulphite.

116. Add ehlorine water or hydrochloric acid and a drop or two of chloride of soda ( $\text{ClNa}$ ); bromine is liberated, and tinges the fluid yellow. On adding a few drops of carbonic disulphide,  $\text{CS}_2$ , and shaking up, the bromine is dissolved by the  $\text{CS}_2$ , which becomes more or less deeply coloured reddish brown.

117. Mixed with  $\text{MnO}_2$  and sulphuric acid, and heated, bromine vapour of a reddish brown colour is evolved, which will colour paper moistened with starch *yellow*. (Distinction from iodine.)

HYDRIODIC ACID,  $\text{HI}$ .—*Potassic iodide*.

118. Argentic nitrate produces a yellowish white ppt. of  $\text{AgI}$ , which is insoluble in dilute nitric acid, very sparingly soluble in ammonia, but readily soluble in potassic cyanide.

119. Treated as in 116, iodine is liberated, which gives the  $\text{CS}_2$  a beautiful purple colour. The solution containing the liberated iodine before the  $\text{CS}_2$  is added, if poured into starch paste, turns it *blue*.

120. Mixed with  $\text{MnO}_2$  and sulphuric acid, and heated in a long test tube, iodine vapour of a purple or violet colour is evolved, which colours paper moistened with starch paste *blue*, and condenses on the cool part of the tube in grey crystals.

HYDROSULPHURIC ACID,  $\text{SH}_2$ .—*Hydric ammonic sulphide*.

121. Heated with  $\text{HCl}$ , sulphuretted hydrogen gas is evolved, known by its odour and the black tinge it imparts to paper moistened with plumbic acetate. The addition of a strip of zinc is necessary in the case of some sulphides which are insoluble in  $\text{HCl}$ .

122. Soluble sulphides give a black ppt. of  $\text{PbS}$  when plumbic acetate is added, and a fine yellow ppt. of  $\text{CdS}$  with a soluble cadmic salt.

NITROUS ACID.— $\text{NOHo}$ .—*Potassic nitrite*.

123. A solution of ferrous sulphate,  $\text{SO}_2\text{Feo}$ , acidified with a few drops of  $\text{SO}_2\text{Ho}$ , is turned dark brown by a solution of a nitrite.

124. A dilute solution of potassic iodide, made acid with a few drops of  $\text{HCl}$ , to which is added some starch paste, gives the fine blue iodide of starch on the addition of a nitrite.

## GROUP III.

**Acids which are not precipitated by any reagent :—**NITRIC ACID.— $\text{NO}_2\text{Ho}$ .—*Potassic nitrate*.

125. The solution in a test tube is mixed with some strong solution of ferrous sulphate,  $\text{SO}_2\text{Feo}$ , in the cold, and pure strong sulphuric acid is poured gently down the side of the test tube, held in a slanting position, so that it may not mix with the solution. The presence of



$\text{NO}_2\text{Ho}$  will be indicated by a *purple* or *brown* colour at the plane of contact of the two liquids.

126. Heated with copper turnings and strong sulphuric acid, nitric oxide is evolved, which becomes red in the upper part of the tube from absorption of oxygen.

127. A nitrate heated on charcoal deflagrates (burns suddenly with sparks). See 130.

CHLORIC ACID,  $\left\{ \begin{array}{l} \text{OCl} \\ \text{OHo} \end{array} \right.$ .—*Potassic chlorate*.

128. Chlorates heated with strong  $\text{HCl}$  evolve euchlorine, a gas having a deep greenish-yellow colour and a peculiar offensive odour.

129.—The solution is slightly coloured with indigo solution (sulph-indigotic acid), dilute sulphuric acid, and then sulphurous acid or a sulphite is added. The blue colour disappears.

130. A chlorate heated on charcoal deflagrates more violently than a nitrate. Chlorates heated in a test tube first fuse and then give off oxygen gas. The residuc is a chloride.

## ORGANIC ACIDS.

ACETIC ACID,  $\left\{ \begin{array}{l} \text{CH}_3 \\ \text{COHo} \end{array} \right.$ .—*Potassic or Sodie acetate*.

131. Heated with sulphuric acid, vapour of acetic acid is evolved, recognised by its smell of vinegar.

132. Heated with a mixture of equal volumes of strong sulphuric acid and alcohol, vapour of acetic ether is evolved, having a very characteristic odour.

133. Ferric chloride,  $\text{Fe}_2\text{Cl}_6$ , produces a dark red colour in solutions of acetates. On boiling for some time the fluid loses its colour, a basic acetate of iron being precipitated in bulky brownish-yellow flocks.

FORMIC ACID,  $\left\{ \begin{array}{l} \text{H} \\ \text{COHo} \end{array} \right.$ .—*Sodie formate*.

134. Heated with strong sulphuric acid carbonic oxide is evolved, which burns with a fine blue flame. See 106.

135. Formic acid and formates by their reducing action readily precipitate the metals from solutions of salts of gold, silver, or mercury. They also decolourise a solution of potassic permanganate.

TARTARIC ACID,  $\bar{\text{T}}\text{Ho}_2$ .—*Tartaric acid or Rochelle salt*.

136. Tartaric acid and tartrates when heated give off the odour of burnt sugar; tartaric acid leaves a residue of carbon; tartrates leave a finely-divided mixture of carbon and a carbonate, oxide or metal.

137. To a neutral solution add argentic nitrate,  $\text{NO}_2\text{Ag}$ , filter, wash the ppt. of tartrate of silver, and then dissolve it off the filter with a little dilute ammonia; pour the solution into a *clean* test-tube or flask, which must then be immersed in warm water for some time, when the interior of the vessel will become coated with a brilliant silver mirror.

138. Calcic chloride,  $\text{CaCl}_2$ , gives a white ppt. of calcic tartrate in the cold, soluble in cold potassic or sodic hydrate.

CITRIC ACID,  $\text{C}_3\text{H}_5\text{O}_7$ .—*Citric Acid*.

139. Argentic citrate dissolved in dilute ammonia does not yield a metallic mirror on warming. See 137.

140.—Calcic chloride,  $\text{CaCl}_2$ , gives no ppt. in the cold, but a ppt. is obtained on heating; this ppt. is insoluble in cold potassic or sodic hydrate. Distinction from tartaric acid.

HYDROCYANIC ACID (Prussic acid),  $\text{HCy}$ .—*Potassic cyanide*.

N.B. As cyanides are extremely poisonous only small quantities must be used, and breathing prussic acid vapours should be avoided.

141. Place a small quantity of the cyanide in a beaker, add a little dilute sulphuric acid, when prussic acid will be evolved, known by its odour of bitter almonds. Moisten a dish with a few drops of yellow ammoniac sulphide and place it over the beaker. Ammoniac sulphocyanide will be formed, which, when washed off the dish into a beaker, and acidulated with  $\text{HCl}$ , will give a blood red solution on the addition of ferric chloride,  $\text{Fe}_2\text{Cl}_6$ .

142. To a solution of a cyanide add sodic hydrate, then a mixture of a ferrous and ferric salt, and lastly acidify with  $\text{HCl}$ , when Prussian blue will be formed.

OXALIC ACID.—See 105 and 106.

# SYSTEMATIC COURSE OF ANALYSIS.

## PRELIMINARY EXAMINATION.

Should the substance be in solution a portion must be evaporated to dryness and the residue examined. If the substance be a solid it must be reduced to a fine powder in a mortar.

Both single salts and mixtures may be examined, as below.

In the case of mixtures, some of the reactions of the preliminary examination may be obscured or destroyed by the substances acting on one another. The examination in the wet way will, however, reveal the presence of any substance not indicated.

A considerable amount of useful information may be obtained by examining the physical characters of the substance: its crystalline form should be noticed, its odour, lustre, density, hardness, and colour. A good magnifying lens will be of service in this examination. The following table will assist the student, but he must make due allowance for mixed colours, and especially for light-coloured substances, which may be obscured by admixture with dark colors :—

1. The substance is colourless . Crystallised or vitreous compounds of K, Na, Am, Ba, Sr, Ca, Mg, Al, Zn, Hg, Pb, Bi, Cd, As, Sn, Sb, Ag.
2. The substance is white . Anhydrous salts of the above ; also oxides and hydrates of K, Na, Ba, Sr, Ca, Mg, Al, Zn, Bi, As, Sb, Sn.
3.    "       "       black . Sulphides of Ag, Hg, Pb, Cu, Bi, Sb, Fe, Co, Ni. **MnO<sub>2</sub>**, **CuO**, **Ni<sub>2</sub>O<sub>3</sub>**.
4.    "       "       red . . **HgO**, **'Cu'<sub>2</sub>O**, **Pb<sub>3</sub>O<sub>4</sub>**, **Fe<sub>2</sub>O<sub>3</sub>**, **K<sub>6</sub>Fe<sub>2</sub>Cy<sub>12</sub>**, **PtCl<sub>4</sub>** **Cr<sub>2</sub>O<sub>5</sub>KO<sub>2</sub>**, vermilion (**HgS**), Co salts.
5.    "       "       yellow . Chromates of K, Na, Am, Ba, Sr, Ca, Bi, Pb, **K<sub>4</sub>FeCy<sub>6</sub>**, **CdS**, **As<sub>2</sub>S<sub>3</sub>**, **SnS<sub>2</sub>**.
6.    "       "       green] . Some salts of Cu, **SO<sub>2</sub>Feo''**, **SO<sub>2</sub>Nio''**, **FeHo<sub>2</sub>**, chromic salts, manganates.
7.    "       "       blue . Some salts of Cu, anhydrous Co salts. Prussian blue.

## PRELIMINARY EXAMINATION FOR BASES, &amp;c.

**A.**—Heat a small portion of the powder in a bulb tube\* in the Bunsen flame, or before the blowpipe:—

1. The substance changes colour . . . Heavy metallic oxides.

It is yellow whilst hot, white on cooling . . . } **ZnO.**

It becomes yellow when cold . . . } **PbO.**

From white to dirty light yellow . . . } **SnO<sub>2</sub>.**

From white to dull yellow . . . } **Bi<sub>2</sub>O<sub>3</sub>.**

Becomes reddish-brown when cold . . . } **Fe<sub>2</sub>O<sub>3</sub>.**

If one of the above reactions be obtained pass on to **D**, if the substance be a single salt or base.

2. The substance fuses and solidifies } Most alkaline salts, and many  
on cooling . . . } salts of the alkaline earths.

Pass on to **C** and **E**.

3. The substance is wholly or partly } Hg, As, Am' compounds, vola-  
volatile . . . } tile acids, &c.

Reddish-brown drops, yellow when cold, condense on the cold part of the tube . . . } Sulphur, or a sulphide.

The substance melts, giving off heavy fumes, which condense as a white sublimate . . . } **HgCl<sub>2</sub>.**

It sublimes without fusion . . . } '**Hg'**<sub>2</sub>Cl<sub>2</sub>.

The sublimate is black, but when rubbed turns red . . . } **HgS.**

The sublimate consists of white octahedral crystals, plainly visible if examined under a lens } **As<sub>2</sub>O<sub>3</sub>.**

The sublimate is yellow . . . } **HgI<sub>2</sub>. As<sub>2</sub>S<sub>3</sub>.**

A violet vapour fills the tube . . . } Iodine

Heavy white fumes, and a white crystalline sublimate . . . } Oxalic acid.

4. The substance gives off water with or without fusion . . . } Hydrates, or salts containing water of crystallisation,

The water is alkaline to test paper . . . } Ammonium compounds.

„ acid „ . . . } Free volatile acids, or acid salts.

The substance swells up, and then shrinks . . . } Alums, borates, phosphates.

5. The substance gives off a gas.

The gas is oxygen. . . } Chlorates, perchlorates, nitrates, peroxides.

Reddish-brown nitrous fumes . . . } Nitrates of heavy metals.

Cyanogen is evolved, known by its odour of bitter almonds . . . } Cyanides of heavy metals.

\* A short piece of  $\frac{3}{16}$  in. glass tubing, closed at one end, which is heated at the closed end in the Bunsen flame, and blown into a small bulb.



- Ammonia gas is given off . . . } Some salts of ammonium and moist cyanates.  
 Chlorine gas . . . . . } Certain chlorides, chlorates, and hypochlorites.

6. The substance blackens, giving off } Organic matter.  
     a tarry odour .. . . . }  
     A smell of burnt sugar is given off. Tartaric acid, 136, 137.  
     Pungent and irritating acid fumes Citric acid, 140.  
     A carbonate mixed with carbon is } Salts of organic acids.  
     left . . . . . }

**B.**—If under **A** the substance is not volatile, pass on to **C**; but if wholly or partly volatile, examine as follows:—

- Mix the substance in a wide test-tube, dish or mortar, with  $\text{NaHO}$  or quick lime, and a few drops of water.  
     Ammonia gas is evolved . . . . Ammonium compound.
- Heat the dry substance with dry  $\text{CONaO}_2$  or black flux, in a bulb tube:—  
     Globules of mercury sublime . . Hg. compound.  
     A dark steel-grey mirror is formed As.       ,,  
      $\text{NH}_3$  is evolved. . . . . Am.       ,,
- Heat in a test-tube with strong sulphuric acid—  
      $\text{CO}$  and  $\text{CO}_2$  are given off, the  $\text{CO}$  }  
     burns with a blue flame on } Oxalic acid, 106.  
     applying a light . . . . . }

Volatile substances need not be examined by **C, D, E**, or **F**.

**C.**—Heat a little of the powdered substance on charcoal before the blowpipe:—

- The substance decrepitates (crackles)  $\text{NaCl}$ ,  $\text{KI}$ , &c.
- The substance deflagrates . . . . Nitrates, chlorates.
- The substance fuses and sinks into } Alkaline salts.  
     the charcoal . . . . . }
- A white mass is left, highly luminous while heated . . . . . } Alkaline earths,  $\text{Al}_2\text{O}_3$ ,  $\text{ZnO}$ ,  $\text{SiO}_2$ .
- The cold residue of 4, moistened with  $\text{N}_2\text{O}_4$  and heated strongly again, is coloured—  
     Blue . . . . .  $\text{Al}_2\text{O}_3$ , phosphates and silicates.  
     Green. . . . .  $\text{ZnO}$ .  
     Pale pink . . . .  $\text{MgO}$ .
- A coloured residue is left on the }  
     charcoal . . . . . }  $\text{Cu}$ ,  $\text{Co}$ ,  $\text{Ni}$ ,  $\text{Mn}$ ,  $\text{Fe}$ ,  $\text{Cr}$ .

7. An incrustation is left on the charcoal, yellow when hot, white when cold . . . . . } **ZnO.**

8. A reddish-brown incrustation . . . **CdO.**

9. A white incrustation and garlic odour **As<sub>2</sub>O<sub>3</sub>.**

**D.**—Heat on charcoal with **CONaO<sub>2</sub>** and **KCy**, in inner flame of blowpipe.

1. Malleable metallie bead.

White bead, which makes a black mark when drawn across paper with yellow incrustation . . . } **Pb.**

Brilliant white bead, with no incrustation . . . . . } **Ag.**

White bead, slight incrustation . **Sn.**

Yellow bead . . . . . **Au.**

2. Brittle metallic bead.

Lemon yellow incrustation. . **Bi.**

Gives off white fumes when removed from the flame—white incrustation . . . . . } **Sb.**

3. Red scales, or a red somewhat infusible metallie bead . . . . . } **Cu.**

4. Magnetic metallie powders . . . **Fe, Ni, Co.**

**E.**—Hold a fragment of the substance moistened with **HCl** on the loop of a clean platinum wire\* in the hottest part of the Bunsen flame :—

1. The upper part of the flame is coloured green . **Cu** or **BHO<sub>3</sub>.**

2. " " " yellowish green . **Ba.**

3. " " " intensely red . **Sr.**

4. " " " orange red . **Ca.**

5. " " " violet . **K.**

6. " " " yellow . **Na.**

7. " " " blue . **As<sub>2</sub>O<sub>3</sub>, Pb, CuCl<sub>2</sub>, Sb.**

**N.B.** Indistinct flame colourations may be disregarded.

**F.**—Fuse the substance on clear borax bead in outer flame :—

1. The bead is green whilst hot, blue when cold . **Cu.**

2. " blue " blue " **Co.**

3. " reddish brown " lighter coloured " **Ni.**

4. " brownish red " { light yellow or colourless } " **Fe.**

5. " yellowish brown " { colourless, or nearly so } " **Bi.**

6. " amethyst " amethyst " **Mn.**

7. " green " green " **Cr.**

\*See foot note to Table VI.



## ANALYSIS OF A SINGLE SALT, OXIDE, OR ACID.

The student is not expected to find more than one metal and one acid : he must first make a preliminary examination of the substance, as directed at page 26.

## EXAMINATION OF THE SOLUBILITY OF THE SUBSTANCE, AND PREPARATION OF THE SOLUTION.

(a) *For the metal or base.*

Separate small portions of the finely-powdered substance are heated in a test tube for some time successively with water, dilute hydrochloric acid, strong hydrochloric acid, dilute nitric acid, strong nitric acid, and aqua regia, and in this order, till the proper solvent is found for the substance. When found, a sufficient quantity of the powder is dissolved for the analysis.

*Preparation of the substance when it is insoluble in water and acids.*

Should the substance prove to be insoluble in the above fluids, some of the finely-powdered substance is mixed with four or five times its weight of fusion mixture on a large piece of platinum-foil, and heated strongly for some time over the Bunsen flame; or, still better, in the gas or Herapath blowpipe flame. The fused mass, when cold, is then boiled with water, and the liquid filtered off; the residue, which is a carbonate or oxide of the metal, is examined for the metal, and the filtrate for the acid, which is present in the filtrate as a sodic salt. See below C.

(b) *For the acid.*

**A.**—The substance is a solution, or is soluble in water. Proceed at once with the analysis by Table VII.

**B.**—The substance is insoluble in water, but soluble in acids:—

1. An odourless gas is evolved on solution in acid. The acid is carbonic, and no other acid need be looked for. Confirm by 102.
2. A gas smelling of burning sulphur is given off.  
The acid is sulphurous, and no other acid need be looked for. Confirm by 104.
3. A gas smelling of rotten eggs comes off. The acid is hydrosulphuric (sulphuretted hydrogen). No other acid need be looked for. Confirm by 122.
4. No gas is given off on treatment with an acid.  
Boil about 20 grains of the well-powdered substance in solution of sodic carbonate, filter, add excess of nitric acid, boil off  $\text{CO}_2$ , add  $\text{AmHo}$  in slight excess, and examine by Table VII. for the acid.

**C.**—The substance is insoluble in water and acid. Fuse it with four or five times its weight of fusion mixture, and proceed as in preparation of the substance for the detection of the metal or base. Examine filtrate by Table VII.

## GENERAL TABLE FOR THE EXAMINATION OF A SUBSTANCE CONTAINING BUT ONE METAL.

*Determination of the Group to which the Metal belongs.*

To a portion of the solution add HCl.	To the same portion add SH <sub>2</sub> , either in strong solution or by passing the gas into it. If no ppt., or only a white cloud of sulphur appears, pass to next column.*	To another portion add AmCl, AmHo in excess, and SHAm. Pass on to next column if no ppt. is produced.	To a fresh portion add AmCl, AmHo in excess, and COAmO <sub>2</sub> . Pass on to next column if no ppt. is produced.	Metals not precipitated by the preceding Group reagents.
<p>GROUP I.</p> <p>The ppt. is white, and is one of the following chlorides* :—</p> <p>AgCl Hg<sub>2</sub>Cl<sub>2</sub>. PbCl<sub>2</sub>†.</p> <p>Examine the ppt. by Table II.</p>	<p>GROUP II.</p> <p>The metal is precipitated as one of the following sulphides :—</p> <p>HgS black PbS " " CuS " " Bi<sub>2</sub>S<sub>3</sub> " " Au<sub>2</sub>S<sub>3</sub> " " PtS<sub>2</sub> " " CdS yellow As<sub>2</sub>S<sub>3</sub> " " As<sub>2</sub>S<sub>5</sub> " " SnS<sub>2</sub> " " SnS brown Sb<sub>2</sub>S<sub>3</sub> orange.</p> <p>Examine ppt. by Table III.</p>	<p>GROUP III.</p> <p>The metal is precipitated either as a sulphide :—</p> <p>FeS black CoS " " NiS " " MnS flesh-coloured ZnS white, or as a hydrate— Al<sub>2</sub>Ho<sub>6</sub> white gelatinous Cr<sub>2</sub>Ho<sub>6</sub> dirty green or as a phosphate, &amp;c. P<sub>2</sub>O<sub>5</sub>CaO<sub>3</sub> white</p> <p>Examine ppt. by Table IV.</p>	<p>GROUP IV.</p> <p>The metal is precipitated as a carbonate, and is either</p> <p>COBaO" white COSro" " " COCao" " "</p> <p>Examine the ppt. or the original solution by Table V.</p>	<p>GROUP V.</p> <p>The metal is either</p> <p>Mg Am' K Na</p> <p>Examine the original solution by Table VI.</p>

\* A few more drops of hydrochloric acid should be added to the ppt. to make sure that it is not an oxychloride of Sb or Bi, which also precipitates with a small quantity of HCl, but redissolves in excess. Read notes 1 and 2, page 50.

† If the solution be very dilute Pb will not precipitate here, but will be found in Group II.

‡ Should the yellow or red solution become green, the acid of the salt is probably chromic acid, which by reduction becomes a green chromic compound. Confirm by 109, 110, and 111.

TABLE II.

## GROUP I.—EXAMINATION FOR THE METAL IN THE HYDROCHLORIC ACID GROUP.

The hydrochloric acid ppt. is shaken up vigorously in the test-tube, allowed to subside, and the clear liquid poured off. Should the ppt. not subside readily, it may be filtered off. The ppt. is then treated with strong ammonia, and the metal is determined by the column below corresponding to the reaction.

<p>The precipitate is <i>dissolved.</i></p> <p>Add nitric acid in excess.</p> <p>The ppt. is re-precipitated.</p> <p>The metal is <b>SILVER.</b></p> <p>Confirm by 1A and 2*.</p>	<p>The precipitate is <i>blackened.</i></p> <p>The metal is <b>MERCURY,</b> as a mercurous compound.</p> <p>Confirm by 3A and 4.</p>	<p>The precipitate is <i>unchanged</i> in colour.</p> <p>The metal is <b>LEAD.</b></p> <p>Confirm with original solution by 6, 7, and 8.</p>
---	--	--

\* The figures in this and the remaining tables refer to the number of the reaction by which the student is recommended to further test the substance.





## GROUP 3.—EXAMINATION FOR THE METAL IN THE HYDRIC AMMONIC SULPHIDE GROUP.

The ppt. is black. To a portion of the original solution add NaHo.				The ppt. is not black.			
A dirty green ppt. turning brown on exposure to air.  The metal is <b>IRON</b> as a ferrous compound. Confirm by 42, 43, 44.	A bulky brown ppt. The metal is <b>IRON</b> as a ferric compound. Confirm by 38, 39, 40.	A light green ppt. not turning brown on exposure to air. The metal is <b>NICKEL.</b> Confirm by 54, 54A, 55.	A blue ppt. The metal is <b>COBALT.</b> Confirm by 58, 59.	The ppt. is flesh-coloured. The metal is <b>MANGANESE.</b> Confirm by 61, 63, 64.	The ppt. is bluish-green. The metal is <b>CHROMIUM.</b> Confirm by 49, 50, 51, 52.	The ppt. is white. Add pure NaHo to a portion of the original solution.	
						A white ppt. which redissolves when more NaHo is added: add to this solution AmCl.	A white ppt., which is insoluble in excess. The metal is a phosphate, borate, or fluoride of Ba, Sr, Ca, or Mg. To determine the metal, proceed according to the directions given in the footnote.*
				A white ppt. The metal is <b>ALUMINIUM.</b> Confirm by 46, 48.		No. ppt. The metal is <b>ZINC.</b> Confirm by 67.	

\* **A.** Test a portion of the original solution for  $\text{POHo}_3$  by 94; if absent, pass on to B; if present, add more  $\text{Fe}_2\text{Cl}_6$  to the solution, boil, filter, and test filtrate for the metals by Tables V. or VI.

**B.** Test a portion of the original solution for  $\text{BHo}_3$  by 100; if absent, pass on to C; if present, boil some of the original substance with  $\text{CONaO}_2$ , filter, wash ppt., dissolve it in HCl, and test the solution for the metal by Table V. or VI.

**C.** Test a fresh portion of the original solution for HF by 107; if present, heat some of the powder with strong  $\text{SO}_2\text{Ho}_2$  on platinum-foil, ignite residue, and then fuse it with fusion mixture; boil the fused mass with water, filter, wash ppt., dissolve it in HCl, and test the solution for the metal by Table V. or VI.

## GROUP 4.—EXAMINATION FOR THE METAL IN THE AMMONIC CARBONATE GROUP.

A portion of the original solution, which must be neutral or but slightly acid,\* is treated with calcic sulphate,  $\text{SO}_2\text{Cao}''$ , in the cold, and the metal determined by the column below corresponding to the reaction.

<p>There is a white ppt. <i>immediately</i>.</p> <p>The ppt. is <math>\text{SO}_2\text{Bao}''</math>.</p> <p>The metal is</p> <p><b>BARIUM.</b></p> <p>Confirm by 69, 70, 71.</p>	<p>There is a white ppt. after <i>standing some time</i>, or after shaking or stirring and warming.</p> <p>The ppt. is <math>\text{SO}_2\text{Sro}''</math>.</p> <p>The metal is</p> <p><b>STRONTIUM.</b></p> <p>Confirm by 73, 74.</p>	<p>There is no ppt. even after standing ten minutes.</p> <p>To a fresh portion of the original solution add ammonia in excess and ammoniac oxalate.</p> <p>There is a white ppt. of</p> $\left\{ \begin{array}{l} \text{CO} \\ \text{CO} \end{array} \text{Cao}'' \right.$ <p>The metal is</p> <p><b>CALCIUM.</b></p> <p>Confirm by 77.</p>
---	---	---

\* If the solution contain much free acid, it must be expelled by evaporating the fluid nearly to dryness in a dish; a little water may then be added.

GROUP V.—EXAMINATION FOR THE METALS WHICH ARE NOT PRECIPITATED BY ANY GENERAL REAGENT.  
SEPARATE PORTIONS OF THE ORIGINAL SOLUTION ARE TESTED AS UNDER.

<p>To a portion of the original solution, or to that in which <b>COAmO<sub>2</sub></b> has failed to give a ppt. Add <b>AmCl</b>, <b>AmHo</b>, and <b>POHoNaO<sub>2</sub></b>:—</p> <p>A white crystalline ppt. (78)</p> <p>The metal is</p> <p><b>MAGNESIUM.</b></p> <p>Confirm by 79.</p>	<p>The presence or absence of</p> <p><b>AMMONIUM</b></p> <p>will already have been determined in the preliminary examination. If not, it must now be tested for by 86, 87.</p>	<p>Take a drop of the strong solution, or a fragment of the solid substance, on the loop of a clean* platinum wire, and hold it in the lower part of the Bunsen flame, or in the blowpipe flame.</p>
<p>The flame is coloured <i>golden yellow</i>.</p> <p>The metal is</p> <p><b>SODIUM.</b></p> <p>Confirm by 84.</p>	<p>The flame is coloured <i>violet</i>, and is <i>reddish purple</i> or <i>magenta</i> colour when seen through cobalt glass.</p> <p>The metal is</p> <p><b>POTASSIUM.</b></p> <p>Confirm by 80, 81.</p>	

\* The wire may be cleaned by dipping it repeatedly in strong **HCl** or **SO<sub>2</sub>Ho<sub>2</sub>**, and then holding it in the hottest part of the Bunsen flame until it ceases to colour the flame. The wire should be fused into a short piece of glass tubing at one end and kept in water or **HCl**, and will then always be nearly clean.

TABLE VII.

GENERAL TABLE FOR THE EXAMINATION OF A SUBSTANCE CONTAINING BUT ONE ACID. DETECTION OF THE ACID.

*Prepare the solution of the substance according to the directions given on page 29.*

Group I.—Acids precipitated by  $\text{BaCl}_2$  from their neutral or alkaline solutions.—Add  $\text{BaCl}_2$  to a portion of the solution, which must be neutral, or made slightly alkaline by ammonia  $\text{AmHo}$ . (Note 1.) Should the  $\text{AmHo}$  produce a ppt., filter it off before adding the  $\text{BaCl}_2$ .

There is a ppt. Add Water and then  $\text{HCl}$  in excess.The ppt. dissolves (Note 2). Heat a portion of the original substance with dilute  $\text{HCl}$  in a wide test-tube.

No gas or vapour is evolved, except the  $\text{HCl}$ . Set aside the  $\text{HCl}$  solution for further examination. To another portion of the original solution, made slightly alkaline by  $\text{AmHo}$ , diluted with water, and filtered if necessary, add  $\text{CaCl}_2$  in the cold.

There is no ppt. (Note 3.) Examine by the columns below.

There is a ppt. (Note 3.) Add Acetic Acid in excess.

The ppt. does not dissolve. Test as below.

The ppt. dissolves. Test as below.

Pass on to Group II.

The acid is **SULPHURIC**.

Group I. is absent.

The gas comes off in effervescence, and is odourless, or nearly so.

The acid is **CARBONIC** Confirm by 102.

If the solution for analysis has been prepared by B4 or C (page 29), the evolution of carbonic acid must be disregarded, & another acid looked for.

The original solution is yellowed.

Add plumbic acetate to a portion of it.

A yellow ppt. of chrome yellow.

The acid is **CHROMIC**. Confirm by 108, 110.

Dip a piece of Turmeric paper into the  $\text{HCl}$  solution.

The part immersed becomes red.

The acid is **BORIC**. Confirm by 101.

Add  $\text{SH}_2$  to another portion of the  $\text{HCl}$  solution.

A yellow ppt.

The acid is **ARSENIOUS**. Refer to Table I., Group II., and Confirm by 36A, 35.

Boil a portion of the original substance with strong sulphuric acid for some time.

The substance blackens.

The acid is **CITRIC**. Confirm by 139, 140.

A gas is given off which burns with a blue flame.

The acid is **OXALIC**. Confirm by 106, 106A.

Boil a portion of the original substance with strong sulphuric acid.

The substance quickly blackens.

The acid is **TARTARIC**. Confirm by 137, 138.

Test a portion of the original substance for

**HYDROFLUORIC** acid by 107.

Acidify a small portion of the original substance with strong nitric acid.

Add ammonio molybdate in large excess, and warm nearly to boiling.

A heavy yellow ppt.

The acid is **PHOSPHORIC**. Confirm by 93, 94.

Evaporate a small portion of the  $\text{HCl}$  solution to dryness on the water bath in a small dish or watch-glass.

Moisten dry residue with  $\text{HCl}$ , warm, and add water.

White flakes of  $\text{SiO}_2$  remain undissolved.

The acid is **SILICIC**.

Confirm by 99, 99A.



TABLE VII.—Continued.

37

## GROUP II.—ACIDS PRECIPITATED FROM THEIR SOLUTIONS BY ARGENTIC NITRATE.

To a portion of the original solution made neutral with ammonia add Argentic nitrate  $\text{NO}_2\text{Ag}$ .

There is a ppt. (Note 2).—add dilute nitric acid.

There is no ppt.  Pass on to Group III.	The ppt. does not dissolve (Note 2). Shake and pour off clear liquid.			The ppt. dissolves.
	The ppt. is white, and is dissolved by strong ammonia.	The ppt. is yellow or has a yellow tinge. To another portion of the original solution add a few drops of chlorine water, or $\text{HCl}$ , and chloride of soda, and then a few drops of $\text{CS}_2$ , and shake up.	The ppt. is black.	
Group II. is absent.	Mix a portion of the original substance with $\text{MnO}_2$ and strong sulphuric acid, and warm.	The $\text{CS}_2$ is coloured dark brown.	The acid is	The sharp smell of vinegar is given off. The acid is <b>ACETIC</b> . Confirm by 132, 133.
	Chlorine gas is given off. The acid is <b>HYDROCHLORIC</b> . Confirm by 114.	The acid is <b>HYDROBROMIC</b> . Confirm by 117.	The acid is <b>HYDRO-SULPHURIC</b> . Confirm by 121.	
	To a portion of the original solution add $\text{NaHfO}_4$ , then ferric chloride, and lastly $\text{HCl}$ , and warm. Prussian blue is produced. The acid is <b>HYDROCYANIC</b> . Confirm by 141.	The $\text{CS}_2$ is coloured violet. The acid is <b>HYDRIODIC</b> . Confirm by 120.	The acid is <b>HYDRO-SULPHURIC</b> . Confirm by 121.	The sharp smell of peroxide of nitrogen are given off. The acid is <b>NITROUS</b> . Confirm by 123, 124.

GROUP III.—ACIDS WHICH ARE NOT PRECIPITATED BY EITHER  $\text{BaCl}_2$  OR  $\text{NO}_2\text{Ag}$ .To a portion of the original substance add dilute  $\text{HCl}$ , and warm.

The solution turns yellow, and a yellowish green gas is evolved, having a chlorous odour. The acid is <b>CHLORIC</b> . Confirm by 129, 130.	The solution remains colourless. To a portion of the original solution add ferrous sulphate, and then pour down the side of the test tube strong $\text{SO}_2\text{H}_2\text{O}_2$ . There is a brown ring where the liquids meet. The acid is <b>NITRIC</b> . Confirm by 126.	
	The sharp smell of vinegar is given off. The acid is <b>ACETIC</b> . Confirm by 132, 133. Acetic acid is tested for here, as, owing to the sparing solubility of Argentic Acetate, it may have been overlooked in Group II.	

## ANALYSIS OF MIXTURES.—DETECTION OF THE BASES.

---

*Substances containing more than one acid and one base.*

A preliminary examination of the substance must be made according to the directions given on page 26. It must, however, be remembered that some of the reactions of the preliminary examination may be obscured or destroyed by the substances acting on one another. Due allowance must also be made for possible mixture of colours; light coloured substances may be obscured by dark coloured ones.

Preparation of the substance for analysis of the bases.

- A. The substance is in solution; proceed at once with the analysis by the following tables, commencing with Table VIII.
- B. The substance is a solid; reduce it to a fine powder in a mortar. Boil about 20 grains of it in water.
  1. The substance completely dissolves; proceed with the analysis.
  2. The substance does not completely dissolve; filter off a few drops and evaporate to dryness, on platinum-foil. If a residue remains, filter off the whole fluid, exhaust with boiling water, and examine fluid by the tables, and treat the residue insoluble in water by 3.
  3. Heat till effervescence, if any, ceases, *separate* small portions of the residue of 2, or of the original substance if wholly insoluble in water, successively with dilute HCl, strong HCl, strong nitric acid, and aqua regia, and in this order till the proper solvent is found for the substance. When found, a sufficient quantity of the powder is dissolved, and the analysis proceeded with.
  4. Should the substance be insoluble, or only partially soluble in acids, proceed according to the directions on page 29, for a substance insoluble in water and acids.

GENERAL TABLE FOR THE EXAMINATION OF BASES IN MIXTURES CONTAINING MORE THAN ONE METAL.

A	B.	C.	D	E
Group I.  To a portion of the original solution add HCl in excess (Note 1).  <i>A ppt. is produced</i> (Note 2).  Shake vigorously, filter off the ppt., which may contain <div style="text-align: center;"> <math>\text{AgCl}</math>  <math>\text{Hg}_2'\text{Cl}_2</math>  <math>\text{PbCl}_2</math> </div> Examine the ppt. by Table IX., and the filtrate, diluted with water, by Column B.  <i>There is no ppt.</i>	Group II. Saturate the filtrate or solution from A with $\text{SH}_2$ (Note 3), and warm gently. <i>A ppt. is produced</i> (Note 4), which may consist of the following sulphides:— <div style="display: inline-block; vertical-align: middle;"> <math>\text{PbS}</math> black  <math>\text{HgS}</math> " "  <math>\text{CuS}</math> " "  <math>\text{Bi}_2\text{S}_3</math> " "  <math>\text{CdS}</math> yellow  <math>\text{SnS}</math> brown  <math>\text{SnS}_2</math> yellow  <math>\text{Sb}_2\text{S}_3</math> orange  <math>\text{As}_2\text{S}_3</math> yellow  <math>\text{Au}_2\text{S}_3</math> black  <math>\text{PtS}_2</math> " " </div> Filter off, wash ppt. well, and examine it by Table X. Boil filtrate till free from $\text{SH}_2$ (Note 5), add a few drops of $\text{NO}_2\text{H}$ , evaporate to dryness, and ignite residue, if organic matter or acids be present, but not otherwise. Moistened residue with HCl, add water and heat: if insoluble white flakes remain, $\text{SiO}_2$ is present. Filter off and examine filtrate by column C. <i>There is no ppt.</i> Treat the solution as directed above for the filtrate, and examine it by column C.	Group III.  To the solution or filtrate from B. add $\text{AmCl}$ (Note 6), and $\text{AmHo}$ in excess, and then $\text{SHAm}$ and heat gently. <i>A ppt. is produced</i> , which may consist of the following sulphides:— <div style="text-align: center;"> <math>\text{FeS}</math> black.  <math>\text{CoS}</math> " "  <math>\text{NiS}</math> " "  <math>\text{ZnS}</math> white.  <math>\text{MnS}</math> flesh-colour. </div> Also of the following hydrates:— $\text{Al}_2\text{H}_2\text{O}_6$ gelatinous whitish; $\text{Cr}_2\text{Ho}_8$ bluish-green; and also the following phosphates:— <div style="text-align: center;"> <math>\text{P}_2\text{O}_2\text{BaO}''_3</math> white.  <math>\text{P}_2\text{O}_2\text{SrO}''_3</math> " "  <math>\text{P}_2\text{O}_2\text{CaO}''_3</math> " "  <math>\text{P}_2\text{O}_2\text{MgO}''_3</math> " (Note 7). </div> Filter off and wash the ppt. with water containing a little $\text{SHAm}$ . Examine ppt. by Table XI., and the filtrate by column D (Note 8). <i>There is no ppt.</i> Examine the solution by column D (Note 9).	Group IV.  To the solution or filtrate from C (Note 9) add $\text{AmHo}$ and $\text{COAmO}_2$ . <i>A ppt. is produced</i> , which may consist of <div style="text-align: center;"> <math>\text{COBaO}''</math> white.  <math>\text{COSrO}''</math> " "  <math>\text{GOCaO}''</math> " " </div> Heat gently, but not to the boil (Note 10), filter, wash ppt., and examine it by Table XII., and the filtrate by Table XIII.  <i>There is no ppt.</i>  Examine the solution by Table XIII.	Group V.  The solution or filtrate from D may contain— <div style="text-align: center;"> <math>\text{Mg}</math>  <math>\text{K}</math>  <math>\text{Na}</math>  <math>\text{Am}'</math> </div> Examine the solution by Table XIII.

TABLE IX.

40

## GROUP I.—EXAMINATION OF THE PRECIPITATE PRODUCED BY HYDROCHLORIC ACID. (NOTE 1.)

The ppt. is washed once or twice upon the filter with a little cold water, the washings being added to the filtrate; boiling water is then poured over the ppt. in the filter, so long as any of the ppt. dissolves. (NOTE 2.)

<p>The residue may contain  <math>\text{Ag}'\text{Cl}</math>  <math>\text{Hg}'_2\text{Cl}_2</math>.</p> <p>AmHo is poured over the residue in the filter.</p>	<p>The filtrate may contain  <math>\text{PbCl}_2</math>.</p> <p>Add dilute <math>\text{SO}_2\text{Ho}_3</math>.</p> <p>A white ppt.,  <math>\text{SO}_2\text{Pbo}''</math>.</p> <p>Presence of  <b>LEAD.</b></p> <p>Confirm with filtrate by 6, and with ppt, by 8.</p>
<p>There is a black residue (3.)</p> <p>Presence of  <b>MERCURY</b></p> <p>as a mercurous compound.</p> <p>Confirm by treating black residue by 4.</p>	<p>The filtrate may contain  <math>\text{AgCl}</math>.</p> <p>Add excess of dilute <math>\text{NO}_2\text{Ho}</math>.</p> <p>A white curdy ppt. of <math>\text{AgCl}</math>.</p> <p>Presence of  <b>SILVER.</b></p> <p>Confirm by treating ppt. by 2. and original solution by 1a.</p>



TABLE X.

## GROUP II.—EXAMINATION OF THE PRECIPITATE PRODUCED BY SULPHURETTED HYDROGEN.\*

The well-washed ppt. is transferred to a flask, and boiled with NaHo or SHAm for a few minutes, and the residue, if any, must be filtered off and examined by Table X., continued on the next page.

## Subdivision 2.—Sb, Sn, As.

The filtrate or solution is treated with excess of HCl; solution of  $\text{SH}_2$  added: the sulphides of subd. 2, if present, are re-precipitated (Note 1): filter off the ppt. and wash it: neglect the filtrate and washings, digest the ppt. with  $\text{COHoAmo}$  (Note 2) for some minutes, filter and wash well with water containing hydric ammoniac carbonate  $\text{COH}_0\text{Amo}$ .

The residue, if any, may contain  $\text{SnS}_2$  and  $\text{Sb}_2\text{S}_3$ . Dissolve it in strong boiling HCl, adding a few drops of  $\text{NO}_2\text{Ho}$  if necessary, but not otherwise. Introduce the solution into an apparatus evolving pure hydrogen.

The evolved gas, ignited (Note 3), leaves a metallic mirror on cold porcelain, and on the interior of the exit tube, when heated to redness (32).

Presence of

**ANTIMONY.**

Confirm by testing mirror by 32.

Remove the strips of zinc from the hydrogen apparatus, and detach the spongy deposit of metallic tin: dissolve it in strong HCl, dilute with  $\text{OH}_2$ , and add  $\text{HgCl}_2$  (24).

A white or grey ppt.

Presence of

**TIN.**

To the filtrate add excess of HCl.

A yellow ppt.

**As<sub>2</sub>S<sub>3</sub>.**

Presence of

**ARSENIC.**

Confirm by treating ppt. of  $\text{As}_2\text{S}_3$  by 37.

\* Gold and Platinum must be specially tested for in the original solution, by 80 for Pt., and for Au by  $\text{SnCl}_2$ , which gives a purple ppt. (purple of Cassius).

TABLE X. (*continued*).

42

## EXAMINATION OF RESIDUE INSOLUBLE IN NaHo OR SHAm.

*Subdivision 1.*—Hg, Pb, Bi, Cu, Cd.

The residue is washed till free from alkali, and then boiled in a little strong  $\text{NO}_3\text{Ho}$  so long as anything dissolves. Water is then added, and dilute  $\text{SO}_2\text{Ho}_2$ , and the solution set aside; when cold add an equal volume of methylated spirit, and filter.

Boil the solution to expel the aleohol, add excess of AmHo, boil, and filter if necessary.			
<p>The residue may consist of <b>HgS</b>, <b>SO<sub>2</sub>Pbo</b>", and sulphur.</p> <p>Transfer to a boiling tube or flask, add ammonie acetate and AmHo in excess, boil, allow to cool, and filter.</p>	<p>A ppt. is produced.</p> <p>Presence of</p> <p><b>BISMUTH.</b></p> <p>Confirm by dissolving ppt. in a few drops of HCl, evaporate nearly to dryness, and then add a quantity of water. See 13, 14, 15.</p>	<p>To the filtrate or solution add HCl till acid, and pass <b>SH<sub>2</sub></b> gas for some time; filter wash ppt. with solution of <b>SH<sub>2</sub></b>, transfer ppt. to a flask, boil in dilute <b>SO<sub>2</sub>Ho<sub>2</sub></b>, and filter quickly.</p>	
		<p>There is a black residue.</p> <p>Presence of</p> <p><b>COPPER.</b></p> <p>Dissolve residue in <b>NO<sub>2</sub>Ho</b>, and confirm by 16, 17, 18.</p>	<p>The solution may contain <b>SO<sub>2</sub>Cdo</b>"; add AmHo, and excess of <b>SH<sub>2</sub></b>.</p> <p>A yellow ppt.</p> <p>Presence of</p> <p><b>CADMIUM.</b></p> <p>Confirm with ppt. by 22.</p>

TABLE XL.

## GROUP III.—EXAMINATION OF THE PRECIPITATE PRODUCED BY HYDRIC-AMMONIC SULPHIDE.

Dissolve the ppt. in a little dilute HCl, throw in a few small crystals of potassic chlorate (Note 1), and digest in a dish till chlorous odour disappears; filter off sulphur if necessary, and test a small portion of the solution for phosphoric acid by 95; if absent, proceed with remainder of solution as below; if present, by Table XL., continued on next page.

**POH<sub>3</sub> is absent.** Nearly neutralise remainder of solution with **CONaO<sub>2</sub>**, add **COBao**" suspended in OH<sub>2</sub>, shake up in flask or bottle kept corked, set aside for some time, decant the clear liquid, filter off the remainder, and wash with hot water.

To the solution add dilute **SO<sub>2</sub>H<sub>2</sub>O<sub>2</sub>**, boil, set aside for a short time, then filter off the **SO<sub>2</sub>Bao**". Treat filtrate with pure NaHo in excess, boil, filter, and wash ppt.

Dissolve the ppt. in warm dilute HCl, add dilute **SO<sub>2</sub>H<sub>2</sub>O<sub>2</sub>** so long as a ppt. forms, warm, set aside, and filter off **SO<sub>2</sub>Bao**". To filtrate add NaHo (free from **Al<sub>2</sub>O<sub>3</sub>**) in excess, boil for a few minutes, filter and wash ppt.

To the solution add <b>SH<sub>2</sub></b> .	Dissolve the ppt. in a little dilute HCl, nearly neutralise with AmHo, add excess of ammonie or sodic acetate, pass <b>SH<sub>2</sub></b> through the solution for some time, and filter.		
A white ppt. <b>ZnS</b> .	To the solution add AmCl, AmHo in excess, and <b>SHAm</b> .	Dissolve residue in HCl and a crystal of potassic chlorate, nearly neutralise with <b>CONaO<sub>2</sub></b> , add dilute KCy till the ppt. formed just redissolves, boil till free from odour of HCy, cool, add <b>ClNaO</b> , set aside for some time, in a warm place and filter. (See 54A and 58.)	<div data-bbox="893 1460 1053 1709">           Presence of <b>MANGANESE</b>. Confirm with ppt. 63, 64.         </div> <div data-bbox="893 928 1053 1460">           A black ppt., <b>Ni<sub>2</sub>HO<sub>6</sub></b>, Presence of <b>NICKEL</b>. Confirm with ppt. by 55.         </div>
Presence of <b>ZINC</b> .	A flesh-coloured ppt.		<div data-bbox="893 928 1053 1460">           Evaporate filtrate to dryness, and test residue with borax bead (59). Dark blue bead. Presence of <b>COBALT</b>.         </div>

To the solution add dilute HCl in slight excess, then AmHo in slight excess.

A whitish gelatinous ppt. Presence of

**ALUMINIUM.**

Fuse the ppt. on platinum-foil with fusion mixture and **NO<sub>2</sub>K<sub>2</sub>O**, boil the fused mass in water till dissolved, and filter.

Dissolve residue in HCl, add sodic acetate, and then **K<sub>4</sub>FeCy<sub>6</sub>**.  
A dark blue ppt. Presence of

**IRON.**

Test specially for **Fe**" in original solution by 43, 44; and for **'Fe**" by 39 and 40.

The solution or filtrate is yellow; add acetic acid in excess and then plumbic acetate. A yellow ppt. Presence of

**CHROMIUM.**

Test specially for chromic acid and chromic oxide in the original solution.

TABLE XI. (*continued.*)

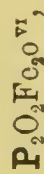
**POHo<sub>3</sub>** is present. Dissolve, digest, and filter off sulphur, as in last table; then nearly neutralise with **CONao<sub>2</sub>**, add ammoniac or sodic acetate and acetic acid in excess, and boil for some time and till the solution is clear; filter hot.

To the solution add **Fe<sub>2</sub>Cl<sub>6</sub>** (Note 2) drop by drop, till the solution has a pink colour, then heat for some time and filter hot.

Digest the ppt. (Note 3) in **SHAm** for some time, and filter.

The solution may contain the metals of the third and fourth groups, and Mg in the fifth. These must be sought for by columns C, D, and E, of the General Table VIII.

Ppt. consists of



and contains all the phosphoric acid previously in combination with the metals now in solution.

The ppt. may be neglected.

The solution contains **POHoAmo<sub>2</sub>**, and excess of **SHAm**, and contains all the phosphoric acid previously in combination with the Fe, Cr, or Al, now in solution.

The ppt. may consist of **FeS**, **Cr<sub>2</sub>Ho<sub>6</sub>**, **Al<sub>2</sub>Ho<sub>6</sub>**.  
Dissolve in HCl, boil with a crystal of potassic chlorate, and examine solution for Al, Fe, and Cr, by Table XI.



## GROUP IV.—EXAMINATION OF THE PRECIPITATE PRODUCED BY AMMONIC CARBONATE.

Dissolve the ppt. in a little dilute HCl, and evaporate solution in a dish to dryness in a water bath. Dissolve a small portion of the residue in water, add  $\text{SO}_2\text{Cao}$ ", and examine the remainder of the residue by the column corresponding to the reaction.

$\text{SO}_2\text{Cao}$ " gives no ppt., even after shaking, warming, and allowing to stand for ten minutes.

Presence of

**C A L C I U M .**

Absence of barium and strontium.

Confirm with remainder of residue by 75.

$\text{SO}_2\text{Cao}$ " gives a ppt. only after standing some time.

Presence of

**S T R O N T I U M .**

Calcium also may be present, but barium is absent.

Dissolve the remainder of the residue (Note 1) in water, boil for some time with  $\text{SO}_2\text{Amo}_2$ , and AmHo. Filter off  $\text{SO}_2\text{Sro}$ ", and confirm presence of strontium by 74, moistening the fragment with strong HCl.

To the filtrate add ammonie oxalate.

A white ppt. (75.)

Presence of

**C A L C I U M .**

$\text{SO}_2\text{Cao}$ " gives a ppt. immediately.

Presence of

**B A R I U M .**

Strontium and calcium may also be present (Note 2).

Pulverise the remainder of the residue in the dish with a pestle, digest with absolute alcohol, filter and wash residue with absolute alcohol.

Dissolve the residue in a little water, and confirm presence of barium by 69, 70, 71.

To the alcoholic filtrate add dilute  $\text{SO}_2\text{Ho}_2$ . Sr. and Ca, if present, are thrown down as sulphates; filter and boil the ppt. for some time with  $\text{SO}_2\text{Amo}_2$  and AmHo; filter.

A residue,  
 $\text{SO}_2\text{Sro}$ ".

Presence of

**S T R O N T I U M .**

Confirm with residue by 74.

Dilute the filtrate or solution with  $\text{OH}_2$ , and add ammonie oxalate.

A white ppt.

Presence of

**C A L C I U M .**

TABLE XIII.

46

GROUP V.—EXAMINATION OF THE FILTRATE FROM THE AMMONIC CARBONATE GROUP, OR OF THE SOLUTION IN WHICH THE GROUP REAGENTS HAVE FAILED TO PRODUCE A PPT.

Evaporate the filtrate or solution to dryness, and ignite residue on platinum-foil till no more ammoniacal fumes come off. Dissolve residue in a little water and a few drops of HCl, if necessary.

<p>To a portion of the solution add AmCl, AmHo, and <b>POHoNa</b><sub>2</sub>, warm, stir well with a glass rod, or shake up, and allow to stand for some time.</p> <p>A white crystalline ppt.</p> <p>Presence of <b>MAGNESIUM.</b></p>	<p>Take up a drop of the remainder of the solution (Note 1) on the loop of a clean platinum wire, and hold it in the outer portion of the lower part of the Bunsen flame, or in the inner cone of the blowpipe flame.</p> <p><i>a.</i> The flame is coloured violet.</p> <p>Presence of <b>POTASSIUM.</b></p> <p>Absence of Sodium. Confirm by <b>S0.</b></p> <p><i>b.</i> The flame is golden yellow.</p>	<p>The presence or absence of <b>AMMONIUM</b></p> <p>will already have been determined in the preliminary examination; if not, it must now be tested for in the original substance by <b>S6, S7.</b></p>
<p>The yellow flame appears purple or magenta colour when seen through cobalt glass. Presence of both <b>POTASSIUM</b> and <b>SODIUM.</b></p> <p>Confirm K by <b>80.</b></p>	<p>The yellow flame cannot be seen through blue cobalt glass. Presence of <b>SODIUM.</b></p> <p>Absence of Potassium.</p>	

## ANALYSIS OF MIXTURES: DETECTION OF THE ACIDS.

## PRELIMINARY EXAMINATION.

Heat a small portion of the substance or solution with dilute HCl.

- a. 1. No gas or vapour is evolved. Absence of carbonates, sulphites, acetates, nitrites, and, possibly, sulphides and cyanides. Prepare the solution for the analysis.
2. A white ppt. is formed (Ag, 'Hg', and Pb being absent), presence of both  $\text{SH}_2$  and  $\text{SOHo}_2$ .
- b. A gas or vapour is given off.
  1. The gas is odourless . . . . . Presence of Carbonic acid.
  2. The gas smells of burning sulphur . . . . . „ Sulphurous acid.
  3. The gas smells of rotten eggs . . . . . „ Hydrosulphuric acid
  4. The sharp smell of vinegar is evolved . . . . . „ Acetic acid.
  5. Nitrous gas is evolved . . . . . „ Nitrous acid.
  6. There is a smell of bitter almonds . . . . . „ Hydrocyanic acid.

If b, 2, 3, 4, or 5 be obtained the gas must be passed through water, and then into lime water, to prove the presence or absence of carbonic acid.

## PREPARATION OF THE SUBSTANCE FOR THE ANALYSIS.

**A.**—The substance is an aqueous solution, or is entirely soluble in water.

Treat a small portion of the solution with sodic carbonate.

1. No precipitate is produced. Carefully neutralise with ammonia if acid, and with nitric acid if alkaline, and proceed with the analysis. See p. 50, Note 1, Table VII.
2. A ppt. is produced by sodic carbonate. Take a larger portion of the solution and add to it sodic carbonate so long as a ppt. is formed, then boil and filter add nitric acid in slight excess to filtrate, boil off the  $\text{CO}_2$  and neutralise back with ammonia, and then proceed with the analysis. The acids are in the filtrate. Nitric acid must be tested for in the original substance.

**B.**—The substance is only partially soluble in water. Filter off the aqueous solution and treat it as in **A**. Wash the portion insoluble in water with hot water, and treat residuc with HCl or aqua regia; if soluble in these acids treat solution as in **A**, testing for the acid which has been used as the solvent in a portion of the original substance.

If the residue be insoluble in acids treat it as in **C**.

**C.**—The substance is insoluble in water and acids.

The finely-powdered substance is mixed with four or five times its weight of fusion mixture, and fused on a large piece of platinum-foil, or, better still, a small platinum capsule, over the Bunsen flame, till quite fluid. The fused mass is then boiled with water, filtered, the filtrate boiled with slight excess of nitric acid, neutralised back with ammonia, and the analysis proceeded with. The acids, together with nitric acid, are in the filtrate.

The following substances are insoluble in water and acids:—Silica and most native silicates, sulphates of barium, strontium, and lead; chloride, bromide and iodide of silver, chloride of lead, ignited oxides of aluminium, chromium, iron, tin and antimony, fluoride of calcium, sulphur, and carbon.

TABLE XIV.

GENERAL TABLE FOR THE EXAMINATION FOR ACIDS IN A MIXTURE CONTAINING MORE THAN ONE ACID.

Prepare the solution for analysis according to directions given on page 47.

In the examination for bases the following acids, if present, will have been met with: Arsenious, Arsenic, Silicic chromic; and in the preliminary Examination for Acids, page 47, the following carbonic, sulphurous, acetic, nitrous, and possibly hydrosulphuric and hydrocyanic.

GROUP I.

To a portion of the prepared solution, which must be neutral or slightly alkaline, add **BaCl<sub>2</sub>**.

There is a ppt. (Note I.) Add dilute HCl in excess.

The ppt. completely dissolves (Note I.) Sulphuric acid is absent.  
To another portion of the prepared solution, which must be neutral or made very slightly alkaline by ammonia and diluted with water, add **CaCl<sub>2</sub>** in the cold.

There is a ppt.

Test separately as in Table VII. for

Phosphoric Acid,

Oxalic "

Tartaric "

Hydrofluoric "

Also as in previous column for

Boric Acid,

Citric "

Pass on to Group II.

There is

no ppt.

Pass on

to Group II.

Group I. is

absent.

The ppt. does not dissolve (Note I.) sulphuric acid is present.

Examine original solution by next column.

There is no ppt.

Test separately as in Table VII. for

Boric Acid,

Citric "

No other acids of this Group can be present. Chromic and arsenious acid will already have been found if present. Pass on to Group II.



TABLE XIV.—Continued.

GROUP II.—ACIDS PRECIPITATED BY ARGENTIC NITRATE.

To a portion of the prepared solution made acid with nitric acid add argentic nitrate.

There is no ppt.	There is a white curdy ppt., which is freely soluble in excess of AmHo. (Note 1.)	There is a ppt. of a light-yellowish colour, which does not dissolve freely in excess of AmHo. To another portion of the nitric acid solution add excess of HCl, a few drops of CS <sub>2</sub> , and a drop of ClNaO, and shake.	The CS <sub>2</sub> is coloured violet. Presence of <b>HYDRIODIC ACID.</b>  Add more ClNaO, drop by drop, until the violet colour disappears; if the CS <sub>2</sub> bc then yellow, <b>HYDROBROMIC ACID</b> is present.  Test for Hydrochloric Acid as in the preceding column. Also, test specially for Hydrocyanic Acid, if the preliminary examination gave indications of its presence.  Pass on to Group III.
Pass on to Group III. Group II. is absent.	Presence of <b>HYDROCHLORIC ACID.</b>  Confirm by 113. Or <b>HYDROCYANIC ACID.</b>  Confirm by 141, 142.  Absence of Hydrobromic and Hydriodic Acids.  Pass on to Group III.	The CS <sub>2</sub> is coloured brown. Presence of <b>HYDROBROMIC ACID.</b>  The original dry substance is mixed with potassic bichromate and potassic nitrate and fused in a porcelain crucible till all fumes are expelled, poured out of the crucible on a plate of iron while still fluid: it is then broken into small pieces, mixed with strong sulphuric acid in a retort and distilled: the distillate mixed with excess of AmHo gives a yellow solution. (Note 3.) Presence of <b>HYDROCHLORIC ACID.</b>  Test specially for Hydrocyanic Acid, if indicated in the preliminary examination.  Pass on to Group III.	

GROUP III.—ACIDS WHICH ARE NOT PRECIPITATED BY BaCl<sub>2</sub> OR NO<sub>2</sub> AGO.

Nitric and Chloric Acids :  
All nitrates and chlorates are soluble in hot water.  
To a portion of the aqueous solution of the original substance add sulphuric acid and sulphindigotic acid.

- The blue colour is not destroyed. Absence of Group III.
- The blue colour is destroyed.  
Test for NITRIC ACID by 125, 126.  
" CHLORIC " 128, 130.

## EXPLANATORY NOTES TO THE TABLES.

## NOTES TO TABLE VII.

Note 1.—For analysis, a solution is made alkaline by adding ammonia till it turns red litmus blue, and it is made acid by the addition of nitric or hydrochloric, till the solution turns blue litmus red. Solutions are made neutral by slightly acidifying with nitric acid, if not already acid, boiling off  $\text{CO}_2$ , if present, then adding ammonia in slight excess, and boiling in a dish till all smell of ammonia passes off.

Note 2.—If commercial sodic carbonate has been used for the fusion,  $\text{BaCl}_2$  and  $\text{NO}_2$  will give a slight precipitate, owing to presence of sulphates and chlorides, as impurities. A slight precipitate may, therefore, be disregarded.

Note 3.—A strong solution of a borate is precipitated by  $\text{CaCl}_2$ . A very dilute solution of a tartrate is only precipitated by  $\text{CaCl}_2$ , after standing some time.

## NOTES TO TABLE VIII.

The separation of the metals into groups is based on the following facts:—

1. Insolubility of the chlorides of the 1st Group in dilute  $\text{HCl}$ .
2. " " sulphides " 2nd " "
3. " " " " 3rd "  $\text{SHAm.}$
4. " " carbonates " 4th "  $\text{AmHo.}$
5. Solubility of the salts of the 5th Group in all the foregoing reagents.

Note 1.—If  $\text{HCl}$  has been used to dissolve the substance, pass at once to B.

Note 2.—If the original solution be alkaline,  $\text{HCl}$  may precipitate silicic and boric acids,  $\text{Al}_2\text{Ho}_6$ , also the sulphides of Subdivision 2, Group II. The ppt. in this case is best examined separately. The oxychlorides of Bi, Sb, and Sn may also precipitate on the first addition of  $\text{HCl}$ , but they redissolve on adding more  $\text{HCl}$ , and warming the fluid.

Note 3.—It is preferable to pass the gas through the solution until a little of the clear solution or filtrate ceases to give any further ppt. with it. If arsenic be present, the solution should be hot whilst passing the gas; and if it be suspected that the arsenic exists as arsenic acid, the solution must be previously treated with sulphurous acid to reduce it to arsenious acid.

Note 4.—Should  $\text{SH}_2$  merely produce a white ppt. of sulphur which remains suspended in the fluid, it may be neglected. This reaction indicates the presence of oxidising agents, such as free Cl, Br, I, also of chloric, iodic, bromic, nitric, and chromic acids, or of a ferric salt.

If the solution be not sufficiently diluted, or if it contain too much  $\text{HCl}$ ,  $\text{SH}_2$  sometimes throws down a brick-red ppt. of  $\text{PbS, PbCl}_2$ .

Note 5.— $\text{SH}_2$  is expelled in order to prevent formation of  $\text{SO}_2\text{Ho}_2$ , which would precipitate Ba, Sr, and probably Ca as sulphates.

The nitric acid is added for the purpose of destroying organic matter and organic acids, which prevent the precipitation of ferric and aluminic salts.

The solution must, in any case, be evaporated to dryness, in order to convert any *silica* into the insoluble form, since the soluble modification might be easily mistaken for alumina. The dry residue should not be strongly heated if it can be avoided, since many of the oxides are redissolved with considerable difficulty after ignition.

Note 6.—Ammonic chloride is added here to prevent the precipitation of magnesium in any other form than the phosphate.

Note 7.—Small quantities of the *oxalates*, *borates*, and *fluorides* of the *alkaline earth metals* may also be obtained in this precipitate, but need not be regarded, since their bases will always be detected in the filtrate, and the acids cannot be overlooked in the ordinary method of examination for acids.

The metals which are precipitated by **SHAm** as sulphides and hydrates will be precipitated as phosphates if they are present as such in the original solution.

Note 8.—Should this filtrate have a brown colour, indicative of dissolved *sulphide of nickel*, it is evaporated until the excess of **SHAm** is expelled, acidified with dilute hydrochloric acid, the precipitate thrown upon the filter, and examined together with that previously obtained.

Note 9.—Should none of the general reagents previously used have produced a precipitate, a portion of the original solution may be examined by D, having previously added AmCl to prevent precipitation of magnesia.

Note 10.—The solution containing the ppt. should not be boiled, as the carbonates of Group IV. are thereby converted into soluble chlorides when in presence of  $\text{AmCl}$ ; and the metals would therefore pass again into solution.

## NOTES TO TABLE IX.

The separation of the metals in this group is based upon—

1. The solubility of  $\text{PbCl}_2$  in boiling water.
2. The solubility of  $\text{AgCl}$  in  $\text{AmHo}$ .
3. The conversion of  $\text{Hg}_2\text{Cl}_2$  by  $\text{AmHo}$  into the insoluble black compound,  $\text{NH}_4\text{Hg}_2\text{Cl}$ .

Note 1.—See Note 2, Table VIII.

Note 2.—Should this precipitate contain very much *plumbic chloride*, it should be boiled with successive quantities of water, until a portion of the solution, decanted into a watch-glass, no longer crystallises on cooling.

## NOTES TO TABLE X.

The separation of this group into two Subdivisions is based upon—

- a. The solubility of the sulphides of Subdivision 2 in NaHo or SHAm.  
b. The insolubility " " " "

The separation of the metals in Subdivision 1 depends on—

1. The insolubility of  $\text{HgS}$  in nitric acid.
2.        "         $\text{BiHo}_3$  in  $\text{AmHo}$ .
3.        "         $\text{CuS}$  in dilute  $\text{SO}_2\text{Ho}_2$ .
4. The solubility of  $\text{CdS}$         "        "



The separation of the metals in Subdivision 2 depends on—

1. The solubility of  $\text{As}_2\text{S}_3$  in  $\text{COHoAmo}$ .
2. The evolution of Sb as  $\text{SbH}_3$  in Marsh's apparatus.
3. The precipitation of metallic tin in " "

Note 1.—If HCl in excess produce no ppt. the metals of Subdivision 2 are absent.

Note 2.—This reagent is prepared by dissolving the carbonate of ammonia, or sal volatile of the shops, in cold water *without* adding ammonia.

Note 3.—The hydrogen gas must not be ignited until all the air is chased out of the apparatus.

#### NOTES TO TABLE XI.

The subdivision of the metals of Group III. depends upon—

- a. The precipitation of the hydrates of 'Fe"', Al, and Cr, by  $\text{COBao}$ ".
- b. The solubility of Zn, Mn, Ni, and Co, in presence of  $\text{COBao}$ ".

The separation of the metals in (a) is based upon—

1. The solubility of  $\text{Al}_2\text{Ho}_6$  in NaHo.
2. The conversion of Cr into a soluble, and 'Fe"' into an insoluble form by fusion with fusion mixture.

The separation of the metals in (b) depends on—

1. The solubility of  $\text{ZnHo}_2$ , in NaHo.
2. "  $\text{MnS}$  in acetic acid.
3. The formation of an insoluble compound of Nickel ( $\text{Ni}_2\text{Ho}_6$ ), and of a soluble compound of Co, by treating their cyanides with  $\text{ClNaO}$ .

Note 1.—This is done in order to convert the Fe into the ferric condition, as  $\text{SHAm}$  has reduced it into a ferrous form.

Note 2.—Test a portion of the solution with a drop of  $\text{Fe}_2\text{Cl}_6$ , and if no ppt. is formed, the solution may be at once examined by C, D, and E of the General Table VIII.

Note 3.—This ppt. may consist of the phosphates of  $\text{Fe}_2\text{O}^{\text{VI}}$ ,  $\text{Cr}_2\text{O}^{\text{VI}}$ , and  $\text{Al}_2\text{O}^{\text{VI}}$ .

These metals may be separated with greater accuracy as follows:—

The ppt. is dried, fused on platinum with  $\text{SiO}_2$ , fusion mixture, and  $\text{NO}_2\text{Ko}$ .

Dissolve in hot water, add  $\text{COAmo}_2$ , digest, allow to subside, and filter.

*Filtrate*, if yellow, contains the Cr. as a soluble chromate. Test by 111, adding first excess of acetic acid.

*Residue*, dissolve in HCl, evaporate to dryness, moisten with strong HCl, treat with hot water, and filter off  $\text{SiO}_2$ . To the solution add excess of pure NaHo, heat, and filter.

*Precipitate* is  $\text{Fe}_2\text{Ho}_6$ ; dissolve and confirm by 38, 40.

*Filtrate*, add slight excess of HCl, then slight excess of AmHo; a ppt. indicates presence of Al as phosphate.

#### NOTES TO TABLE XII.

The separation of the metals in this group depends on—

1. The insolubility of  $\text{BaCl}_2$  in absolute alcohol.
2. "  $\text{SO}_2\text{Sro}$ ", in solution of  $\text{SO}_2\text{Amo}_2$ .
3. The solubility of calcium salts in  $\text{SO}_2\text{Amo}_2$ .



Note 1.—Strontium may also be separated from the insolubility of its nitrate in absolute alcohol, calcic nitrate being soluble in it. If this process be employed, it will be necessary to convert the remainder of the residue into nitrate, first by means of  $\text{COAmo}_2$ , and then  $\text{NO}_2\text{Ho}$ .

Note 2.—Barium may also be separated from Sr and Ca by means of  $\text{H}_2\text{SiF}_6$  and alcohol; also by  $\text{CrO}_2\text{Ko}_2$  in an acetic solution of the metals; but these processes are inferior to the one given in the table.

#### NOTES TO TABLE XIII.

Note 1.—If much magnesian salts be present, they should first be removed as follows: To the main portion of the remaining solution add  $\text{BaCl}_2$  to remove  $\text{SO}_2\text{Ho}_2$ , warm, set aside, and filter. To filtrate add  $\text{BaHo}_2$  water, or lime water, drop by drop, as long as  $\text{MgHo}_2$  precipitates; filter off  $\text{MgHo}_2$ , and remove Ba or Ca from the filtrate by  $\text{COAmo}_2$ ; heat gently and filter. Evaporate filtrate to dryness, and ignite to volatilise ammoniac salts, and test residue for potassium and sodium by the flame test, as in the table.

#### NOTES TO TABLE XIV.

Note 1.—As commercial sodic carbonate usually contains sulphates and chlorides, it will be necessary to test for sulphuric and hydrochloric acids in a nitric acid solution of the original substance.

Note 2.—If nitrates, chlorates, and chlorides be all present, the chlorides must be first separated by  $\text{SO}_2\text{Ago}_2$ , and the solution evaporated to dryness, and the dry mass mixed with sodic carbonate and ignited strongly. A chlorate, if present, will be converted into a chloride, and a nitrate into a nitrite, both of which may be detected by using the respective tests.

Note 3.—In this distillation chlorochromic acid  $\text{CrO}_2\text{Cl}_2$ , is formed, which produces ammoniac chromate and ammoniac chloride when treated with  $\text{AmHo}$ . A bromide yields bromine under this treatment.

---

## THE SOLUBILITY OF SALTS.

The following Table has been compiled chiefly from Storer's Dictionary of Solubilities, and it is believed it will be useful to the student for reference in cases of doubt as to the nature of a precipitate or solution.

It will also enable the student to save time which would otherwise be spent in looking for substances which could not possibly exist in the compound under examination. For example, suppose a salt *soluble in water* is found to contain lead, on referring to the Table it will be seen that the salt must be either the acetate or nitrate, which are pretty freely soluble in water, or the chloride, bromide, iodide, or borate, which are but sparingly soluble in water; and the student need only search for the acids which can only possibly be present, namely, acetic, nitric, hydrochloric, hydrobromic, hydriodic, or boric. Again, a sulphate which is insoluble in water and acids can only contain barium, strontium, or lead, and these are the only metals which need be looked for.

The solubility of a compound is indicated by the letter placed at the junction of the column in which it is soluble in water by the *w* which is placed in the column under the name of the compound.

*w* signifies that the compound is soluble in water.

*a* signifies that the compound is soluble, and (*a*) signifies that the compound is soluble in ammonium.

*i* signifies that the compound is insoluble.

	Aluminium.	Ammonium.	Antimony.	Arsenic.	Barium.	Bismuth.	Cadmium.	Calcium.	Chromium.	Cobalt.	Copper.	Gold.	Hydrogen.
Acetate .....	<i>w</i>	<i>w</i>	...	...	<i>w</i>	<i>w</i>	<i>w</i>	<i>w</i>	<i>w</i>	<i>w</i>	<i>w</i> *	...	<i>w</i>
Arseniate .....	<i>a</i>	<i>w</i>	<i>a</i>	...	...	<i>a</i>	...	<i>w</i>	<i>a</i>	<i>a</i>	<i>a</i>	...	<i>w</i>
Arsenite .....	...	<i>w</i>	<i>a</i>	...	( <i>w</i> )	...	...	...	...	<i>a</i>	<i>a</i>	...	<i>w</i>
Borate .....	( <i>w</i> )	<i>w</i>	...	...	( <i>w</i> )	( <i>w</i> )	<i>w</i>	( <i>w</i> )	( <i>w</i> )	( <i>w</i> )	( <i>w</i> )	...	<i>w</i>
Bromide .....	<i>w</i>	<i>w</i>	<i>w</i>	<i>w</i>	<i>w</i>	<i>w</i>	<i>w</i>	<i>w</i>	<i>w</i>	<i>w</i>	<i>w</i>	<i>w</i>	<i>w</i>
Carbonate .....	...	<i>w</i>	...	...	<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>	...	<i>w</i>
Chlorate .....	<i>w</i>	<i>w</i>	...	...	<i>w</i>	<i>w</i>	<i>w</i>	<i>w</i>	<i>w</i>	<i>w</i>	<i>w</i>	...	<i>w</i>
Chloride .....	<i>w</i>	<i>w</i>	<i>w</i> *	<i>w</i>	<i>w</i>	<i>w</i> *	<i>w</i>	<i>w</i>	<i>w</i>	<i>w</i>	<i>w</i>	<i>w</i>	<i>w</i>
Chromate .....	...	<i>w</i>	<i>a</i>	...	<i>a</i>	<i>a</i>	<i>a</i>	<i>w</i>	<i>a</i>	( <i>w</i> )	( <i>w</i> )	...	<i>w</i>
Citrate .....	<i>w</i>	<i>w</i>	...	...	<i>a</i>	...	<i>a</i>	<i>w</i>	<i>w</i>	<i>w</i>	<i>w</i>	...	<i>w</i>
Cyanide .....	...	<i>w</i>	<i>a</i>	...	<i>w</i>	<i>a</i>	( <i>w</i> )	<i>w</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>w</i>	<i>w</i>
Ferricyanide...	...	<i>w</i>	...	...	...	...	...	<i>w</i>	...	<i>i</i>	..	...	<i>w</i>
Ferrocyanide ..	...	<i>w</i>	...	...	<i>w</i> - <i>a</i>	...	...	<i>w</i>	...	<i>i</i>	<i>i</i>	...	<i>w</i>
Fluoride .....	<i>a</i> - <i>i</i>	<i>w</i>	<i>w</i>	<i>w</i>	<i>a</i>	<i>w</i>	( <i>w</i> )	<i>a</i> - <i>i</i>	<i>w</i>	( <i>w</i> )	( <i>w</i> )	<i>w</i>	<i>w</i>
Iodide .....	...	<i>w</i>	<i>a</i>	( <i>w</i> )	<i>w</i>	<i>a</i>	<i>w</i>	<i>w</i>	<i>w</i>	<i>w</i>	...	<i>a</i>	<i>w</i>
Nitrate.....	<i>w</i>	<i>w</i>	...	...	<i>w</i>	<i>w</i> *	<i>w</i>	<i>w</i>	<i>w</i>	<i>w</i> *	<i>w</i>	<i>w</i>	<i>w</i>
Oxalate.....	<i>a</i>	<i>w</i>	<i>a</i>	...	<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>w</i>	<i>a</i>	<i>a</i>	...	<i>w</i>
Oxide .....	( <i>a</i> )	<i>w</i>	<i>a</i> - <i>i</i>	( <i>w</i> )	( <i>w</i> )	<i>a</i>	<i>a</i>	( <i>w</i> )	<i>a</i> - <i>i</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>w</i>
Phosphate ...	<i>a</i>	<i>w</i>	<i>w</i>	<i>w</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>w</i>
Silicate .....	<i>a</i> - <i>i</i>	...	...	...	<i>a</i>	...	...	<i>a</i> - <i>i</i>	...	...	<i>a</i>	...	( <i>w</i> )
Sulphate .....	<i>w</i>	<i>w</i>	<i>w</i>	...	<i>i</i>	<i>w</i>	<i>w</i>	<i>w</i>	<i>w</i>	<i>w</i>	<i>w</i>	<i>w</i>	<i>w</i>
Sulphide .....	<i>a</i>	<i>w</i>	<i>a</i>	<i>a</i>	<i>w</i>	<i>a</i>	<i>a</i>	<i>w</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>w</i>
Sulphite .....	<i>a</i>	<i>w</i>	<i>a</i>	...	<i>a</i>	<i>a</i>	( <i>w</i> )	<i>w</i>	<i>w</i>	<i>a</i>	<i>w</i>	...	<i>w</i>
Tartrate .....	<i>w</i>	<i>w</i>	<i>a</i>	<i>w</i>	<i>a</i>	( <i>w</i> )	( <i>w</i> )	( <i>w</i> )	<i>w</i>	<i>w</i>	<i>a</i>	...	<i>w</i>

The oxides and hydrates of the following metals are soluble in water.

The oxides and hydrates of the following metals are soluble in ammonium.

\* The basic salt of these metals is soluble.

# SOLUBILITY OF SALTS.

55

of the perpendicular and horizontal row, thus: Acetate of lead is shown to be "Lead" in the horizontal line in which "acetate" is found.

soluble, and (*w*) slightly soluble in water.

with difficulty soluble in hydrochloric or nitric acid, or aqua regia.

water, hydrochloric or nitric acid, or aqua regia.

Iron Diad.	Iron Pseudo-triad.	Lead.	Magnesium.	Manganese.	Mercury Pseudo-monad.	Mercury Diad.	Nickel.	Platinum.	Potassium.	Silver.	Sodium.	Strontium.	Tin Diad.	Tin Tetrad.	Zinc.
<i>w</i>	<i>w</i> *	<i>w</i>	<i>w</i>	<i>w</i>	( <i>w</i> )	<i>w</i>	<i>w</i>	...	<i>w</i>	( <i>w</i> )	<i>w</i>	<i>w</i>	<i>w</i>	<i>w</i>	<i>w</i>
<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>	...	<i>w</i>	<i>a</i>	<i>w</i>	<i>a</i>	...	<i>a</i>	<i>a</i>
<i>a</i>	<i>a</i>	<i>a</i>	...	...	<i>a</i>	<i>a</i>	<i>a</i>	...	<i>w</i>	<i>a</i>	<i>w</i>	( <i>w</i> )	<i>a</i>	<i>a</i>	...
<i>a</i>	( <i>w</i> )	( <i>w</i> )	( <i>w</i> )	( <i>w</i> )	...	( <i>w</i> )	<i>w</i>	...	<i>w</i>	( <i>w</i> )	<i>w</i>	( <i>w</i> )	( <i>w</i> )	...	( <i>w</i> )
<i>w</i>	<i>w</i>	( <i>w</i> )	<i>w</i>	<i>w</i>	<i>a</i>	( <i>w</i> )	<i>w</i>	<i>w</i>	<i>w</i>	<i>i</i>	<i>w</i>	<i>w</i>	<i>w</i>	<i>w</i>	<i>w</i>
<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>w</i>	<i>a</i>	<i>w</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>
<i>w</i>	<i>w</i>	<i>w</i>	<i>w</i>	<i>w</i>	<i>w</i>	<i>w</i>	<i>w</i>	...	<i>w</i>	<i>w</i>	<i>w</i>	<i>w</i>	<i>w</i>	...	<i>w</i>
<i>w</i>	<i>w</i>	( <i>w</i> )	<i>w</i>	<i>w</i>	<i>a</i>	<i>w</i>	<i>w</i>	<i>w</i>	<i>w</i>	<i>i</i>	<i>w</i>	<i>w</i>	<i>w</i>	<i>w</i>	<i>w</i>
...	<i>a</i>	<i>a</i>	<i>w</i>	<i>w</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>w</i>	<i>a</i>	<i>w</i>	( <i>w</i> )	<i>a</i>	<i>a</i>	<i>w</i>
<i>w</i>	<i>w</i>	<i>a</i>	<i>w</i>	<i>w</i>	<i>a</i>	<i>w-a</i>	<i>w</i>	...	<i>w</i>	<i>a</i>	<i>w</i>	<i>a</i>	...	...	<i>w-a</i>
<i>a-i</i>	<i>w</i>	<i>a</i>	<i>w</i>	<i>w</i>	<i>w</i>	<i>w</i>	<i>a</i>	( <i>a</i> )	<i>w</i>	( <i>a</i> )	<i>w</i>	<i>w</i>	...	...	<i>a</i>
<i>i</i>	<i>w</i>	<i>w-a</i>	<i>w</i>	<i>i</i>	...	...	<i>i</i>	...	<i>w</i>	<i>i</i>	<i>w</i>	...	<i>i</i>	...	<i>a</i>
<i>i</i>	<i>i</i>	<i>a</i>	<i>w</i>	<i>a</i>	...	...	<i>i</i>	...	<i>w</i>	<i>i</i>	<i>w</i>	<i>w</i>	<i>i</i>	<i>i</i>	<i>a-i</i>
<i>w-a</i>	<i>w</i>	<i>a</i>	<i>a-i</i>	<i>a</i>	<i>a</i>	<i>w</i>	( <i>w</i> )	<i>w</i>	<i>w</i>	<i>w</i>	<i>w</i>	<i>a</i>	<i>w</i>	( <i>w</i> )	( <i>w</i> )
<i>w</i>	<i>w</i>	( <i>w</i> )	<i>w</i>	<i>w</i>	<i>a</i>	( <i>a</i> )	<i>w</i>	<i>a</i>	<i>w</i>	<i>i</i>	<i>w</i>	<i>w</i>	( <i>w</i> )	( <i>w</i> )	<i>w</i>
<i>w</i>	<i>w</i>	<i>w</i> *	<i>w</i>	<i>w</i>	<i>w</i> *	<i>w</i> *	<i>w</i> *	<i>w</i>	<i>w</i>	<i>w</i>	<i>w</i>	<i>w</i>	<i>w</i>	<i>w</i>	<i>w</i>
<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>w</i>	<i>w</i>	<i>a</i>	<i>w</i>	<i>a</i>	<i>a</i>	<i>w</i>	<i>a</i>
<i>a</i>	( <i>a</i> )	<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>w</i>	<i>a</i>	<i>w</i>	( <i>w</i> )	<i>a</i>	<i>a-i</i>	<i>a</i>
<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>	...	<i>w</i>	<i>a</i>	<i>w</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>
<i>a</i>	<i>a</i>	...	<i>a-i</i>	<i>a-i</i>	...	...	<i>a</i>	...	<i>w</i>	...	<i>w</i>	<i>a</i>	...	...	<i>a</i>
<i>w</i>	<i>w</i> *	<i>a-i</i>	<i>w</i>	<i>w</i>	<i>w</i>	<i>w</i> *	<i>w</i>	<i>w</i>	<i>w</i>	( <i>w</i> )	<i>w</i>	<i>i</i>	<i>w</i>	<i>w</i>	<i>w</i>
<i>a</i>	<i>a</i>	<i>a</i>	<i>w</i>	<i>w</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>w</i>	<i>a</i>	<i>w</i>	<i>w</i>	<i>a</i>	<i>a</i>	<i>a</i>
<i>w</i>	( <i>w</i> )	<i>a</i>	<i>w</i>	<i>w</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>w</i>	<i>w</i>	<i>a</i>	<i>w</i>	<i>a</i>	( <i>w</i> )	<i>w</i>	( <i>w</i> )
<i>w-a</i>	<i>w</i>	<i>a</i>	<i>w-a</i>	<i>w</i>	<i>a</i>	<i>a</i>	<i>a</i>	...	( <i>w</i> )	<i>a</i>	<i>w</i>	( <i>w</i> )	( <i>w</i> )	<i>w</i>	( <i>w</i> )

potassic or sodic hydrate, As, Sb, Sn, Au, Pb, Zn, Al, Cr.

hydrate or ammonic salts, As, Ag, Cu, Cd, Co, Ni, Mn, Zn, Mg.

hydrochloric or nitric acid, or aqua regia.



## ANALYSIS OF A SINGLE SALT—STATEMENT OF RESULTS (EXAMPLE).

## PRELIMINARY EXAMINATION.

Reaction obtained.	Acid, Metal, or Salt indicated.
<b>A.</b> 5. Reddish brown nitrous fumes.	A nitrate.
<b>B.</b>	
<b>C.</b> 2. The substance deflagrates.	A nitrate or chlorate.
4. A white mass is left, highly luminous.	Alkaline earth, &c.
<b>D.</b>	
<b>E.</b> 2. Yellowish green flame.	Barium.
<b>F.</b>	

TABLE I. THE METAL.—THE SUBSTANCE IS SOLUBLE IN WATER.

Group I. HCl No ppt. Absent Ag Hg' Pb	Group II.—SH <sub>2</sub> No ppt. Absent Hg'', Pb, Cu, Bi Au, Pt, Cd, As Sn, Sb.	Group III. AmCl, AmH <sub>2</sub> O, & SHAm No ppt. Absent Fe, Co, Ni, Mn Zn, Al, Cr P <sub>2</sub> O <sub>2</sub> Cao <sub>3</sub> .	Group IV. AmCl, AmH <sub>2</sub> O, & COAmo <sub>2</sub> . A ppt. Present Ba Sr or Ca.	Group V.
--	--	--	--	----------

## REAGENTS USED.

## METAL INDICATED.

TABLE V.—Group IV.—SO<sub>2</sub> Cao''—ppt. immediately.

Barium.

Confirmed by 69. CrO<sub>2</sub> Ko<sub>2</sub>—yellow ppt.70. H<sub>2</sub>SiF<sub>6</sub>—colourless crystalline ppt.

The Metal is—Barium.

TABLE VII.—THE ACID.

Group I.—BaCl <sub>2</sub> —no ppt. Absent SO <sub>2</sub> Ho <sub>2</sub> , COHo <sub>2</sub> , SOHo <sub>2</sub> , CrO <sub>2</sub> Ho <sub>2</sub> BHo <sub>3</sub> , A <sub>3</sub> Ho <sub>3</sub> , ĊiHo <sub>3</sub> , ŌHo <sub>2</sub> , T <sub>2</sub> Ho <sub>2</sub> HF, POHo <sub>3</sub> , SiHo <sub>4</sub>	Group II.—NO <sub>2</sub> Ago, no ppt. Absent HCl, HCy, HBr HI, SH <sub>2</sub> , ĀHo NOHo	Group III.—No ppt. With BaCl <sub>2</sub> or NO <sub>2</sub> Ago. Present Chloric. Nitric, or Acetic.
--	---	---

## REAGENTS USED.

## ACID INDICATED.

Group III.—Dilute HCl and warmed—solution colourless—no gas. Nitric Acid.

SO<sub>2</sub> Feo'' and SO<sub>2</sub> Ho<sub>2</sub>—brown ring.

Do.

Confirmed by 126.—Copper turnings and SO<sub>2</sub> Ho<sub>2</sub>—red fumes.

The Acid is—Nitric Acid.

The Salt is—Baric Nitrate.

Name—JOHN JONES.



# I N D E X.

	PAGE		PAGE
Acid, Acetic...	23, 37	Cobalt ... ..	16, 28, 33
„ Arsenious ... ..	14, 36	Colour of Substances ...	25
„ Boric ... ..	20, 28, 36	Copper ... ..	12, 28, 32
„ Carbonic ... ..	20, 36	Directions to Students ...	7
„ Chloric ... ..	23, 26, 37	Group I. ... ..	11, 31, 40
„ Chromic ... ..	21, 30, 36	„ II. ... ..	12, 32, 41
„ Citric... ..	24, 27, 36	„ III. ... ..	14, 33, 43
„ Formic ... ..	23	„ IV. ... ..	17 34, 45,
„ Hydriodic ... ..	22, 36, 49	„ V. ... ..	18, 35, 46
„ Hydrobromic... ..	22, 37, 49	Iron ... ..	15, 28, 33
„ Hydrochloric ... ..	21, 37, 49	Lead... ..	11, 28, 32
„ Hydrocyanic ... ..	24, 37, 49	Magnesium... ..	18, 27, 35
„ Hydrofluoric ... ..	21, 36	Manganese ... ..	16, 28, 33
„ Hydrosulphuric ... ..	22, 37	Mercury ... ..	12, 27, 32
„ Nitric ... ..	22, 26, 37	Nessler's Test ... ..	19
„ Nitrous ... ..	22, 37	Nickel ... ..	16, 28, 33
„ Oxalic ... ..	20, 26, 36	Notes to Tables ... ..	50
„ Phosphoric ... ..	19, 27, 36	Potassium ... ..	18, 28, 35
„ Silicic ... ..	20, 27, 36	Preliminary Examination...	27, 47
„ Sulphuric ... ..	19, 36	Preparation of a Solution ...	29, 38, 47
„ Sulphurous ... ..	20, 29, 36	Reactions of the Acids ...	19
„ Tartaric ... ..	23, 27, 36	„ Metals ... ..	11
Aluminium ... ..	15, 27, 33	Reagents . ... ..	9
Ammonium ... ..	18, 27, 35	Results of Analysis, form for...	56
Analysis of a Mixture ...	38	Silver ... ..	11, 28, 31
„ Single Salt ... ..	29	Sodium ... ..	18, 28, 35
Antimony ... ..	13, 28, 32	Solubilities, Table of ...	54
Apparatus, List of ... ..	10	Solubility of Substance ...	29, 38, 47
Arsenic ... ..	14, 27, 32	Strontium ... ..	17, 28, 34
Barium ... ..	17, 28, 34	Tin ... ..	13, 28, 32
Bismuth ... ..	12, 28, 32	Zinc... ..	16, 27, 33
Cadmium ... ..	13, 28, 32		
Calcium ... ..	17, 28, 34		
Chromium ... ..	15, 28, 33		



# Text Books for Science Classes and Schools.

---

## BUCKMASTER'S INORGANIC CHEMISTRY. 3s.

Revised and Corrected by G. JARMAIN.

---

## BUCKMASTER'S EXPERIMENTAL PHYSICS.

Acoustics, Light & Heat. Magnetism & Electricity. 3s.

*From Mr. JOHN BEATTY, Endowed Schools, Oldcastle.*

"I have used your 'Experimental Physics' for the last seven years. I attribute the success of my classes in these subjects to the use of your manual, which, at the price, is the best with which I am acquainted."

---

## BUCKMASTER'S ANIMAL PHYSIOLOGY. 3s.

ILLUSTRATED WITH 97 WOODCUTS.

*From Professor RICHARD OWEN, British Museum, F.R.S., LL.D., &c.*

"I have lost no time in perusing the 'Elements of Animal Physiology.' I think it would be difficult to compress more information on that science, suitable for elementary instruction, into a smaller compass. I shall recommend the work to all who seek information."

---

*On the receipt of Twenty-seven Postage Stamps, addressed J. C. BUCKMASTER, St. John's Hill, Wandsworth, S.W., a copy of any of the above Works will be forwarded.—All P.O. Orders made payable to the same address.*

---

LONDON: LONGMAN & CO.; SIMPKIN, MARSHALL, & CO.  
MANCHESTER: JOHN HEYWOOD.

AND ALL BOOKSELLERS.

GEO. JARMAIN'S  
PRICE LIST OF REAGENTS,

SPECIALLY SELECTED FOR LABORATORY USE, SCIENCE CLASSES  
AND PRIVATE STUDY,

WILL BE FORWARDED ON APPLICATION.

---

A BOOK OF 100 CHEMICAL LABELS, Gummed and Perforated, with Nomenclature and Notation, as used in "Buckmaster's Chemistry." Fifth Edition. Price 3d. ; by post for 3½d. in stamps ; 2s. 6d. per doz.

APPARATUS SUPPLIED as per List in "Buckmaster's Chemistry," pp. 46, 47, and 48, and in "Jarmain's Qualitative Analysis," p. 10, at the prices named therein.

QUOTATIONS GIVEN FOR SETS OF TEST SOLUTIONS, with Bottles ; and SELECTIONS OF SETS OF APPARATUS to order.

STANDARDIZED SOLUTIONS FOR VOLUMETRIC ANALYSIS.

---

84, NORTHGATE, HUDDERSFIELD.



















TABLE(S)  
RUN INTO  
GUTTER